Reports

Board of Scientific Advice for India

1904-05 to 1906-07

00134327

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OF THE
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ANNUAL REPORT

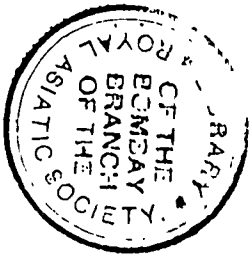
OF THE

BOARD OF SCIENTIFIC ADVICE FOR INDIA

FOR THE YEAR

1904-05.

134327



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IN ENGLAND.

E. Arnold, 41 and 43, Maddox Street, Bond Street, W., London.

Constable & Co., 16, James Street, Haymarket, W., London.

Bernard Quaritch, 15, Piccadilly, W.

Deighton, Bell & Co., Cambridge.

H. S. King & Co., 65, Cornhill, and 9, Pall Mall, London.

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Mr. B. H. Blackwell, 50 and 51, Broad Street, Oxford.

ON THE CONTINENT.

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Otto Harrassowitz, Leipzig.

Karl W. Hiersemann, Leipzig.

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PREFACE.

THE Board of Scientific Advice for India was constituted in 1902, and consisted originally of the heads of the Meteorological, Geological, Botanical, Forest, Survey, Agricultural and Veterinary Departments; but the Government of India intimated their intention to invite from time to time to serve upon it other scientific officers in the service of the Imperial and Provincial Governments, whose special attainments might render their assistance desirable. The Board was declared to be a central authority for the co-ordination of official scientific enquiry, its object being to ensure that the work of research is distributed to the best advantage, that each investigator confines his researches to the subject with which he is most capable of dealing, and that energy is not dissipated by the useless duplication of enquiries or misdirected by a lack of inter-departmental co-operation. It was also hoped that while the claims of abstract science would continue to be recognized in the work of the scientific departments, the Board's advice would aid the Government of India in prosecuting practical research into those questions of economic or applied science, on the solution of which the progressive prosperity of the country, especially as regards its agricultural and industrial development, so largely depends.

The Board advises generally upon the operations of the Departments, with due attention to the economic side of their work, and serves as a reference on all matters connected with the organization of scientific enquiry in India. It annually discusses the proposals of each departmental head in regard to the programme of investigation in his department; and in cases where inter-departmental co-operation is necessary, it advises as to the lines on which mutual assistance should be given and the department to which the enquiry should primarily appertain. It submits annually to the Government a general programme of research, embodying the proposals of departmental heads in so far as its subjects are to be exclusively dealt with in one department, and its own proposals in cases where two or more departments are to co-operate.

And at the end of the year it presents a brief review of the results obtained during the year in all lines of scientific investigation controlled by its members. Its reports and programmes are communicated through the Secretary of State to the Royal Society, who have appointed an Advisory Committee to consider them, and who from time to time furnish the Board and the Government of India with valuable suggestions and advice.

The present members of the Board of Scientific Advice are :

Appointment.	Name.
Secretary to the Government of India in the Department of Revenue and Agriculture. *Ex-officio* President.	Mr. J. WILSON, M.A., C.S.I., I.C.S.
Surveyor-General of India . . .	Colonel F. B. LONGE, R.E.
Meteorological Reporter to the Government of India and Director-General of Indian Observatories.	Dr. GILBERT T. WALKER, M.A., Sc. D., F.R.S.
Director, Geological Survey of India .	Mr. T. H. HOLLAND, F.G.S., F.R.S., A.R.C.S.
Director, Botanical Survey of India .	Captain A. T. GAGE, I.M.S., M.A., M.B., B.Sc., F.L.S., Officiating.
Superintendent, Natural History Section, Indian Museum.	Lt.-Col. A. W. ALCOCK, I.M.S., C.I.E., M.B., LL.D., F.L.S., C.M.Z.S., F.R.S.
Inspector-General of Forests . .	Mr. S. EARDLEY-WILMOT.
Inspector-General of Agriculture . .	Mr. F. G. SLY, I.C.S., Officiating.
Inspector-General, Civil Veterinary Department.	Colonel J. W. A. MORGAN, M.R.C.V.S.
Reporter on Economic Products to the Government of India.	Mr. I. H. BURKILL, M.A., F.L.S., Officiating.

List of Sub-Committees of the Board of Scientific Advice.

Sub-Committee A.—(Meteorology, Terrestrial Magnetism and cognate subjects).

1. The Surveyor-General of India (Chairman);
2. The Meteorological Reporter to the Government of India;
3. The Director, Geological Survey of India.

Sub-Committee B.—(Agricultural Products).

1. The Director, Botanical Survey of India, (Chairman);
2. The Superintendent, Industrial Section, Indian Museum;
3. The Inspector-General of Agriculture.

Sub-Committee C.—(Soils and Manures).

1. The Inspector-General of Agriculture (Chairman);
2. The Director, Geological Survey of India;
3. The Inspector-General of Forests.

Sub-Committee D.—(Forest Products).

1. The Inspector-General of Forests (Chairman);
2. The Superintendent, Industrial Section, Indian Museum;
3. The Director, Botanical Survey of India.

Sub-Committee E.—(Veterinary subjects).

1. The Inspector-General, Civil Veterinary Department (Chairman);
2. The Inspector-General of Agriculture in India;
3. The Superintendent, Natural History Section, Indian Museum.

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ANNUAL REPORT

OF THE

BOARD OF SCIENTIFIC ADVICE FOR INDIA

FOR

1904-05.

SUMMARY OF PROCEEDINGS.

1st Meeting held at Calcutta on 6th February 1903.

IT was recommended that the Superintendent of the Industrial Section of the Indian Museum should be appointed a member of the Board.

The Board approved Major Prain's suggestion that the co-operation of the Forest Department should be invited in collecting timber specimens of the species of Indian trees desired by Mr. Gamble for study in connection with his "Manual of Indian Timbers," the timber specimens to be of a size large enough to admit of a duplicate sample being prepared for the Industrial Section of the Indian Museum, and to be accompanied by botanical specimens taken from the actual tree that yielded the timber specimens, and that the specimens should be sent to the Director of the Botanical Survey for identification.

A note by Mr. Mollison, Inspector-General of Agriculture, on the improvement of cotton fibre and on the cotton-seed oil industry was referred to a sub-committee for report.

A note by Mr. W. H. Moreland, Director of Land Records and Agriculture, United Provinces of Agra and Oudh, was read, in which he stated (*a*) that information was needed on the nature and efficiency of the soil micro-organisms in respect to the fixation of nitrogen; (*b*) that in order to develop the *ghi* industry of Bundelkhand it was desirable to know the flavouring constituents of the various forms of *ghi*, and how the flavour could be regulated; (*c*) that it appeared desirable that a systematic study should be made of the species of Agave which flourish in India, in order to determine whether any bye-products could be prepared from the remains of the plant after its fibre had been extracted, without affecting the fibre. The Board recognised the importance of the first matter mentioned by Mr. Moreland, and asked the Inspector-General of Agriculture to report how far his Department could undertake the investigation. They considered that the investigation into the flavouring constituents of *ghi* could be more appropriately undertaken locally. With regard to the Agave question, they were informed that the systematic study of the species was in hand.

The Reports and Programmes of the Scientific Departments represented on the Board were then considered. With regard to Reports, the general feeling of the Board was that a brief summary of the results obtained in all lines of scientific investigation, based upon the annual departmental Reports and upon papers published by individuals, would suffice. With regard to Programmes, the Board resolved that the head of each department represented on the Board should furnish the Secretary of the Board with a memorandum of the more important questions to be dealt with by his department during the year, and that from these memoranda the Secretary should prepare a programme to be laid before the Board for submission to Government.

2nd Meeting held at Calcutta on 23rd March 1903.

Major Prain was nominated as Secretary.

The Board considered the Report of its sub-committee on the notes of the Inspector-General of Agriculture on (*a*) the improvement of cotton fibre, (*b*) the cotton-seed oil industry. As regards (*a*) the sub-committee recognised the necessity of undertaking a survey of the

species, varieties, races, hybrids and crosses of cotton at present cultivated in India, and recommended that the Reporter on Economic Products, working in conjunction with the Director of the Botanical Survey, should be invited to publish the results of the investigation conducted by his department, after visiting every cotton-producing area to procure the necessary material. They also emphasised the importance of establishing experimental stations for the production of improved seed, and accepted Mr. Mollison's scheme for such a station at Hissar. They were of opinion that the officer in charge of each such station should be an expert in the science of selecting and maturing seed, and that experts would have to be brought from England. With regard to Mr. Mollison's note on the cotton-seed oil industry, the sub-committee recommended that it should be published as an Agricultural Ledger, that a few small consignments of Indian cotton seed from some of the important cotton-growing Provinces should be sent to America for trial in American mills, and that arrangements should be made to obtain a report on the trial from an officer of the United States Department of Agriculture. These recommendations were accepted by the Board.

The Board passed the draft Annual Report for the preceding year.

They then considered the draft programmes of scientific work for the various departments for 1903-04. With reference to those programmes they considered that the preparation of a botanical manual of Indian cultivated plants should be omitted from the programme of the Reporter on Economic Products, as the preparation of such a manual falls more properly to the Botanical Department. They resolved that the question of famine foods mentioned in the programmes, both of the Reporter on Economic Products and the Inspector-General of Agriculture, should be referred to the sub-committee on Agricultural Products before further action was taken. They further resolved that the investigations regarding rubber, cassava cultivation, the production of tapioca flour and the plantain-fibre industry, mentioned in the programme of the Inspector-General of Agriculture, should be referred to the sub-committees concerned for recommendation as to how far the enquiries should be carried on by the different departments. With reference to the programme of the Director of the Geological Survey, they called attention

to the necessity for a revision of the topographical maps of the Jherria and Raniganj coal-fields, and the Director of the Geological Survey was asked to prepare a memorandum stating the reasons for such revision.

The Board resolved that permanent sub-committees should be appointed to deal with special questions as they arose, and that each sub-committee should be empowered to call upon any other member of the Board to join it should it consider his advice on any particular subject desirable.

The Board considered a Despatch from the Secretary of State for India on the subject of the Report of the Imperial Institute, Indian Section, for 1901-02, and referred it for report to a sub-committee.

Two questions were brought forward by the Director of the Botanical Survey, *viz.*, (1) the state of our knowledge of the sources of the various fibres that are used in and are exported from India, (2) the possibility of creating an industry in connection with the extraction of the fibre contained in the flax plant. The Board referred both questions for report to a sub-committee and asked the Reporter on Economic Products to assist in collecting seeds of various fibre plants for experimental cultivation.

The Director of the Geological Survey placed before the Board the following questions :—

(1) Consumption of mineral fertilizers.
(2) Nature of woods suitable for sulphite paper pulp.
(3) Classification of soils and distribution with regard to geological formations.
(4) The magnetic survey of the northern edge of the Deccan trap.
(5) The discharge of the large rivers of India.

The Board resolved that the question of consumption of mineral fertilizers should be referred for report to the sub-committee on Soils and Manures ; and that the investigation regarding the nature of woods suitable for sulphite paper pulp should be referred to the sub-committee on Forest Products. With regard to the classification of soils, it was resolved that the Inspector-General of Agriculture should be asked to furnish the information required regarding the recognized classes of soils. The question of the magnetic survey of the Deccan trap was

noted by the Surveyor-General. With regard to the discharge of the large Indian rivers it was resolved that the Director, Geological Survey, should be asked to submit, through the sub-committee concerned, a more detailed memorandum, and that the Government of India should then be requested to consider the matter in the Public Works Department.

3rd Meeting held at Calcutta on the 11th December 1903.

A letter from the Government of India forwarding correspondence between the Secretary, British Cotton Growing Association, and the Secretary of State for India, on the subject of the survey of existing cottons of India and the improvement of Indian cotton was read, a d referred for report to the sub-committee on Agricultural Products.

A letter was read from the Government of India forwarding papers on the subject of the deterioration of jute communicated by the Government of Bengal. The subject had already been referred for report to the sub-committee on Agricultural Products.

The report of the sub-committee appointed at the previous meeting to consider the suggestions of Professor Dunstan of the Imperial Institute was read, along with a letter from the Government of India, requesting the opinion of the Board with reference to the question of permitting direct correspondence between the Director of the Imperial Institute and the various Government Departments. The Board, agreeing in the findings of the special sub-committee, recommended that whenever the Director of the Imperial Institute had received sanction through the prescribed official channel to originate an investigation, and a particular department in India had been instructed to co-operate, he should be permitted to correspond direct with that department. The Board supported the principle of preserving duplicate samples at Calcutta, but considered that this necessity would be sufficiently met if the Director of the Imperial Institute agreed to transmit to the Reporter on Economic Products, Calcutta, a representative sample of every article examined by him.

A note on the discharge of large rivers by the Director of the Geological Survey was read. Mr. F. J. Spring, who had been invited to attend the meeting of the Board to assist with his expert opinion, explained that the points to be investigated were :—(1) the discharge

of, and (2) the quantity of silt in, the various Indian rivers, and made suggestions as to the manner in which the enquiry might be conducted. It was resolved to strongly recommend the proposed investigation to the favourable consideration of Government.

The Board considered the report submitted by the sub-committee on Agricultural Products on the questions raised at the previous meeting by the Director, Botanical Survey of India, regarding the sources of Indian fibres and the possibility of an industry in connection with the extraction of flax fibre. They accepted the recommendation of the sub-committee that the general question should be dealt with systematically by the Botanical, Economic and Agricultural Departments conjointly. As regards the extraction of fibre from the flax plant they resolved that the Inspector-General of Agriculture should be asked to give the results of his experimental enquiry, when finished, as to whether the plant could profitably be cultivated for fibre as well as for seed. They agreed with the opinion of the sub-committee that the enquiry regarding rubber should be conducted by the Forest Department, but recommended that any chemical investigation in connection with the subject should be entrusted to Professor Dunstan of the Imperial Institute.

The draft Annual Report of the Board as prepared by the Secretary was considered and passed.

The Board resolved that members should be requested, when submitting their Annual Departmental Reports, to append a list of such scientific papers by individuals as bear on the subject with which the department deals.

The question of testing building materials was brought forward by the Director of the Geological Survey, and he was requested to consult the Principal of the Civil Engineering College at Sibpur and to submit a memorandum showing the kind of sample and the character of the information desired by him.

4th Meeting held at Calcutta on the 24th of March 1904.

The Director of the Geological Survey presented a memorandum showing the kind of sample and the character of the information desired in connection with the testing of building materials: and it was resolved that the memorandum should be submitted to the Government of India

with a recommendation that the Department of Public Works should arrange for the collection of the samples, and should send them to the Engineering College at Sibpur, with the request that the Principal would transfer the fragments, which remained after testing, to the Director of the Geological Survey for microscopical examination.

The Board considered a note by the Surveyor-General on the proposed revision of the maps of the Raniganj and Jherria coal-fields, along with a note by the Director of the Geological Survey, and resolved to recommend to the Government of India that the revision be taken up and carried out at an early date.

It was resolved that an additional sub-committee should be formed to advise on veterinary subjects.

An India Office Despatch communicating the observations of the Royal Society's Advisory Committee on the Proceedings of the Board for 1902-03 was read. The Advisory Committee especially alluded in their letter to four questions :—(1) the preparation of a manual of cultivated plants, (2) the desirability of including the Godavari amongst the rivers to be studied as regards discharge of silt, (3) sewage disposal, (4) veterinary bacteriological investigations. With regard to (1) the Advisory Committee endorsed the Board's recommendation. With regard to (2) the Board had already recommended the inclusion of the Godavari amongst the rivers to be investigated. With regard to (3) the Board agreed with the Royal Society's Advisory Committee that the value of investigations regarding sewage disposal would be enhanced by a consultation between investigators in India and those in England. With regard to (4) the Board resolved to appoint a special sub-committee to deal with the subject generally.

The draft programmes of work of the various scientific departments for 1904-05 were considered and passed, with the exception of the programme of the Civil Veterinary Department, which was remitted to the Inspector-General for reconsideration with reference to the remarks made by the Royal Society's Advisory Committee.

5th Meeting held at Calcutta on the 3rd January 1905.

The Board nominated Captain A. T. Gage, I.M.S., to act as Secretary during Lieutenant-Colonel Prain's absence.

A letter from the Government of India, stating that, owing to lack of staff, it was not in a position to carry out the revision of the maps of the Raniganj and Jherria coal-fields, was read and recorded.

The report of the sub-committee on Agricultural Products on the deterioration of jute in Bengal was then read and the Board resolved to accept the report and forward it to the Government of India.

Intimation was received from the Chairman of that sub-committee that it was impossible to submit a report on Indian cotton until the details of the experimental cultivation undertaken by the Agricultural Department had been obtained.

A report by the sub-committee on Forest Products on the question of wood pulp and bamboo pulp for paper-making was then read. The Board requested the sub-committee to give further consideration to the question of the source of the sulphur required by the sulphite process, and to furnish information as to the localities of the principal sulphide ore deposits and of the principal woods of suitable kinds. The Director of the Geological Survey was added to the sub-committee for this special enquiry.

The report of the sub-committee on Veterinary subjects regarding Veterinary bacteriological investigations in India was approved and forwarded to the Government of India.

The draft Annual Report of the Board for 1903-04 was considered and approved.

The President was empowered to refer questions to sub-committees for report to the next meeting of the Board, and in cases of urgency to submit direct to Government the report of the sub-committee. Heads of Departments were requested to send in to the Secretary, at the time of writing their respective annual reports, a summary of the scientific work performed by their respective departments, for incorporation in the Board's Annual Report.

6th Meeting held at Calcutta on the 24th of March 1905.

A letter from the Chairman of the sub-committee on Agricultural Products was read, in which it was intimated that it was as yet premature to put forward a report on the varieties of cotton cultivated in India, until details of the experimental cotton cultures conducted by

the Agricultural Department had been received, and until the sub-committee had learned the latest views of Professor Gammie, who had made the subject a special study. The Board resolved that the Director of the Botanical Survey, the Reporter on Economic Products and Mr. Gammie should be asked to communicate with each other and arrange a scheme of co-operation.

A letter was read from the Chairman of the sub-committee on Soils and Manures, intimating that the information available on the subject of Mineral Fertilizers was not yet ready for the consideration of the Board.

A letter from the Chairman of the sub-committee on Forest Products was read, intimating that a note on the locality of the principal woods and bamboos likely to be suitable for the manufacture of wood pulp was being sent to the Director of the Geological Survey with the request that he would furnish a list of the localities of the principal sulphide ore deposits.

The draft programme of the Board for 1905-06 was considered and was recommended for acceptance to the Government of India.

7th Meeting held at Calcutta on the 11th December 1905.

The Board passed a resolution expressing profound regret at the death of Dr. W. T. Blanford, C.I.E., F.R.S., a member of the Royal Society's Advisory Committee and a retired officer of the Geological Survey of India, whose record of valuable scientific work in connection with Indian Geology, Geography and Zoology covers a period of 50 years.

The Board expressed agreement with the Advisory Committee of the Royal Society as to the great importance, from the economic as well as the scientific point of view, of completing as quickly as possible the general Geological Survey of India and Burma, and strongly recommended an increase in the superior staff of the Geological Department in order to provide a sufficient number of officers for satisfactory progress both in survey and in economic investigations. They also agreed with the Advisory Committee as to the desirability of an organised effort being made towards the Botanical exploration of the areas not yet

investigated, and as to the importance of providing separate floras of the various provinces of India. They recognized that the work could not be undertaken by the staff of Economic Botanists employed by the Local Governments, and recommended that the scientific staff of the Royal Botanic Garden, Sibpur, should be increased to at least four officers, who should devote their attention to the flora of the regions not yet properly surveyed, and compile floras for those portions of the area under the Superintendent of the Royal Botanic Garden for which arrangements have not yet been made. They also recommended that Central India and the Central Provinces should for the purposes of the Botanical Survey be added to that area, and that a fifth officer should be attached to the Botanical survey and placed under the orders of the Director, with a view to providing the latter with a staff sufficient to meet the needs of Madras as well as those of the areas already under his charge. They also suggested that endeavours should be made to find some retired officer willing to undertake the preparation of a Flora of the North-West Himalaya.

The Board recommended that the Physiological investigation into the nature and causes of Lathyrism should be continued, and that a special officer should be deputed for the purpose, subject to the control of the Sanitary Commissioner to the Government of India.

The report of the Sub-Committee on the utilization of Indian timbers for railway sleepers and the production of creosote from Indian coal was forwarded for the information of the Advisory Committee of the Royal Society, with the recommendation that the results of the experiments now being carried on should be awaited. The Board were informed that arrangements were well advanced for the erection of by-product recovery ovenso n the East Indian Railway collieries at Giridih and that steps were being taken for the erection of similar by-product coke-making plant in other coal-fields, and that when those operations were in working order there would probably be a supply of creosote available in Bengal.

With regard to the preparation of a new edition of Sir George Watt's Dictionary of the Economic Products of India, the Board recognised the desirability of a new and revised edition being published as soon as practicable, but considered that it was not desirable for the

work to be undertaken until the abridgement now under preparation had advanced towards completion.

The Board considered the draft Annual Report for 1904-05 and resolved (1) that the report of the work done in the Imperial Institute should be printed as an Appendix to the Report, (2) that the Annual Report should be confined to scientific work done in India or with special reference to India, (3) that the draft section of the report on chemistry should be revised so as to omit all references to work not done on Indian materials. They also desired that their acknowledgements should be conveyed to the contributors of the various sections of the Report.

The Board considered proposals for organising a system of recording the movements of Himalayan Glaciers, which had been put forward through Colonel Burrard, Superintendent of the Trigonometrical Survey, and recommended that the Director of the Geological Survey should be requested to draw up, in consultation with the Surveyor-General, instructions as to the nature of the observations necessary and the methods for recording them, to be communicated to travellers and selected residents in the neighbourhood of the Glaciers to be observed.

Reports on (1) the discharge of silt from Indian rivers, (2) experiments for the improvement of cotton, (3) experiments in growing flax, were forwarded to Government.

ECONOMIC AND AGRICULTURAL CHEMISTRY

BY

J. W. LEATHER, Ph.D., F.I.C., F.C.S.

AND

D. HOOPER, F.C.S., F.L.S.

In dealing with the numerous investigations in this subject it has been considered convenient to arrange the items in the manner adopted in the Report and Programme of the Reporter on Economic Products, and in accordance with the arrangement of the Economic Court of the Industrial Section, Indian Museum.

Gutta.—A specimen of Pontianac from the Patiala State, tested at the Imperial Institute, contained moisture 54·5, resin 36·6, caoutchouc 7·6 per cent. It resembled commercial Pontianac from Singapore in composition and properties.

Gums.—*Anogeissus pendula.* A. Goris and G. Lefevre (*Bull. des. Sc. Pharm.* vol. 6., p. 17) draw attention to the advantages this gum possesses over Acacia gum. It is free from oxydase. The presence of oxydase in gum arabic and not in tragacanth has enabled E. Payet (*Rep. Pharm.* 1904, vol. 16, p. 301) to publish a method of detecting commoner gum in tragacanth when in powder. Numerous samples of gum belonging to species of *Acacia* have been tested by Hooper (*Indian Forester*, Sept. 1904) in regard to their viscosity, tannin, ash and moisture contents. P. Lemeland has tested the gum of the Mango tree, *Mangifera indica*, (*Journ. de Pharm. et Chem.*, 1904, vol 19, p. 584). More than one-third is soluble in water, the solution has a laevorotatory action on polarised light, contains oxydase, and yields arabinose, galactose and pentose on hydrolysis.

Among the resins Dunstan has examined Rock Dammar or resin of *Hopea odorata* from Burma, also Black Dammar the resin of *Canarium bengalense* from Assam. In the Indian Museum, D. Hooper has examined the white resin of *Dipterocarpus pilosus* from Assam, and

the green resin of *Calophyllum Inophyllum*. An investigatian has commenced of the resinous substance known in Burma as Pwe-nyet, a product secreted by species of *Melipona* or Mosquito bee. The fragrant oleo-resin of *Altingia excelsa* has been described and its composition given in the Agricultural Ledger No. 9 of 1904. The adulteration of shellac, which is exported largely from this country, has been the subject of examination with a view to detect impurities. The most recent contribution of importance is a paper by A. C. Langmuir [*Journ. Soc. Chem. Industry*, (1905), vol. 24, p. 12], "on the determination of Rosin in Shellac".

Oils and oils-eeds.—The seeds of the castor-oil plant (*Ricinus communis*) have received great attention at the hands of investigators during the year. Lipase, the lipolytic ferment in castor seed is more active than in other oleaginous seeds. In the presence of an acid lipase is capable of decomposing oils into fatty acids and glycerin in an almost colourless form. Of fatty acid 50 per cent. is set free in 24 hours. Lipase is also capable of decomposing in a similar manner the oils of olive, sesamum and linseed. M. Nicloux (*Comp. rend.* 1904, vol. 138, p. 1175) asserts that the substance possessing these properties in castor seed is the cytoplasma. Whether the cytoplasma is endowed with specific properties or whether it secretes a soluble ferment is a matter for further investigation. In a subsequent paper (*Comp. rend.* vol. 138, p. 1352) M. Nicloux concluded that the hydrolytic properties of the seed are due to the cytoplasma and not to a soluble ferment. L. Maquenne and L. Philippe (*Comp. rend.* 1904, vol. 138, p. 506) describe the constitution of ricinine, $C_8H_8O_2N_2$, a constituent of castor-oil cake. E. Schulze and E. Winterstein (*Zeit. Physiol. Chem.* 1904, vol. 43, p. 211) find that this principle is present in young etiolated or even green plants, to 12- to 15- fold extent than in the seeds; so far tyrosine and leucine have not been found.

The discovery of the true source of the Chaulmoogra seeds of commerce from the tree called *Taraktogenos Kurzii* has been followed by a chemical examination of the expressed oil from the authenticated seeds. The result shows that this oil agrees in its characters with the commercial oil which has been used in leprosy for many years in India, Europe and America. F. B. Power and F. H. Gornall, in a paper entitled

"The Constituents of Chaulmoogra seeds" (*Journ. Chem. Soc.* 1904, vol. 85, p. 838) describe the isolation of chaulmoogric acid, palmitic acid, glycerol and phytosterol. The seeds also contain a hydrolytic enzyme and an unstable cyanogen compound. In a subsequent paper (*Journ. Chem. Soc.* 1904, vol. 85, p. 851) the authors discuss "The constitution of Chaulmoogric acid." Of other fixed oils from plants occurring in India, G. Fendler (*Apoth. Zeit.* 1904, vol. 19, p. 721) has investigated safflower oil (*Carthamus tinctorus*), the oil of *Aleurites moluccana*, useful as a drying oil for varnishes, and that of *Calophyllum Inophyllum* (*Apoth. Zeit.* 1905, vol. 20, p. 6). W. Mooser (*Landw. Versuchs.-Stat.*, 1904, vol. 60, p. 321) has separated a new alkaloid from earth-nut meal (*Arachis hypogaea*) in addition to the bases choline and betaine isolated by Schulze. The new alkaloid termed arachine, possesses poisonous properties. A full account of the oil of *Schleichera trijuga*, known as Macassar oil, has been published as an Agricultural Ledger, No. 1 of 1905.

The oil has been determined by Dr. Leather in the principal oil-seeds of India, each oil-seed being represented by some dozens of samples. The list of seeds examined included *Sesamum indicum*, the *Brassicæ*, *Eruca sativa*, *Guizotia abyssinica*, *Linum usitatissimum*, *Carthamus tinctorius*, *Arachis hypogæa*, *Ricinus communis*, *Papaver somniferum*, *Gossypium*, *Bassia latifolia*. The extreme variation which occurs in each of the crops has thus been ascertained.

E. G. Hill (*Journ. As. Soc. Beng.*, Vol. 1, No. 3, 1905, p. 74) has described the composition of the oil of the Bir Bahoti or "Rain's Insect" (*Trombidium grandissimum*). The author concludes that the oil is principally composed of myristodiolein, and that there are also present small quantities of stearin, cholesterol, and colouring matter. There is possibly also present an alcohol of high molecular weight belonging to the fatty series of carbon compounds.

The following essential oils have been examined :—

Andropogon Schœnanthus.—The essential oil of Ginger grass. Geraniol has been found to be the chief alcohol present.

Erythroxylon monogynum.—The essential oil of the bastard sandal. contains a crystalline compound of an alcoholic character.

Santalum album.—Seidler (*Apoth. Zeit.* 1904, 19, p. 795) describes the physical properties of genuine East Indian sandal wood oil.

Cinnamon.—The value of various kinds of cinnamon barks in cinnamaldehyde has been determined by J. Harries (*Zeit. Nahr. Genussm.* 1904, vol. 7, p. 669). The following amounts of cinnamaldehyde were found:—

Ceylon cinnamon	1·74–2·19
Cassia cinnamon	2·08–3·81
Cassia buds	3·7 –6·0
Cinnamon chips	1·23—1·42
C. Tamala	1·8
C. Kiamis, *Nees*	*Nil.*

Lemongrass oil.—Messrs. Schimmel &Co. of Leipzig have described a modified test for and nature of the adulterant in commercial oils, and have criticised the reliability of Bamber's test for the measure of impurity.

Dyes, Indigo.—As the result of researches conducted in Bihar, Bengal, at least two papers on the subject of the Chemistry of indigo have been contributed to the Chemical Society of London. C. Bergtheil (*Journ. Chem. Soc.* of 1904, vol. 85, p. 870) discusses the "Fermentation of the Indigo Plant," and shows that the fermentation is due to a specific enzyme occurring in the plant cells. The optimum temperature for the action is 50° C., and the temperature at which the enzyme is destroyed is 71°C. The rate of action is decreased by the presence of both acids and alkalis. Various antiseptics all produced inhibition, formalin to the greatest, and boric acid to the least extent. Emulsin can produce the indigo fermentation, but not myrosin. No evidence of the existence of an oxydase in the indigo plant was obtained.

An account of the research work in indigo carried out at Dalsingh Serai Research Station, from 1903 to March 1904, has been written by Messrs. W. P. Bloxam, H. M. Leake and R. S. Finlow, and published by the Government of Bengal. A paper embodying the chemical results of the work has been contributed by W. P. Bloxam (*Chem. Soc., Proc*, vol. 20, p. 159) and entitled "Our present knowledge of the Chemistry of Indigo." The author, after showing that all the methods for the purification of indigo by the use of solvents being open to objection,

devised a test based on the estimation of nitrogen by Kjeldal's method. Pure indigotin should give a nitrogen value of 10·68 per cent., and any substance giving figures below this standard would necessarily be impure. The author has estimated the percentage of nitrogen in the best specimens procurable, and found that they contained only about 90 per cent. of indigotin. The pure substance may be prepared in a crystalline condition by sublimation under diminished pressure. It has also been found that the red substance occurring in the cake obtained from plant indigo, and known as indirubin or "indigo-red," is not, as stated, a derivative of indigo, as it contains no nitrogen.

In a paper (*Journ. Soc. Dyers & Colourists*, 1904, vol. 20, p. 35) on "The Manufacture of indigo from the Indigo plant," C. Rawson shows there is no loss of indigotin, real or apparent, during the drying of natural indigo.

Rawson in 1899 discovered that Java indigo contained a yellow colouring matter. This substance has been examined by A. G. Perkin (*Chem. Soc. Proc.*, vol. 20, p. 172) who finds it to be identical with Kampherol, a colouring matter which has been separated by Gordin from galangal root.

E. G. Hill, in a paper read before the Asiatic Society of Bengal, describes the flowers of the Narsinghar plant (*Nyctanthes Arbor-tristis*) in dyeing, and gives an account of the separation and properties of the yellow crystalline colouring matter. The colouring matters of the flowers of two more Indian plants have been determined by A. G. Perkin. The colouring principle of the flowers of *Thespesia Lampas* consists of quercetin. In the flowers of *Hibiscus Sabdariffa* gossypetin is present, the same substance that occurs in the flowers of *Gossypium herbaceum*.

Tanning materials.—The analyses of new materials and the preparation of tanning extracts have been conducted during the year. W. R. Dunstan has examined a fresh consignment of Divi-Divi pods from Santal Perganahs, Bengal, and found 45·4 per cent. of tannin, a higher result than in any previous sample from India. A new tanning material has been brought to light in Assam. This is the bark of *Artocarpus Lakoocha* which, analysed in the Indian Museum, was found

to contain 8·5 per cent. of tannin. A sample of the root of *Rumex hastatus* from Naini Tal afforded 11·6 per cent. of tannin, and a sample of the root of *Polygonum amplexicaule* gave 15·9 per cent.

Extracts of Mangrove barks continue to interest workers in the leather factories in Europe, and reports are being received on the barks and extracts supplied by various countries. J. Paessler, (*Collegium*, 1904, vol. 91, p. 15) experimenting with mangrove bark as a tanning material, found that leather was fully tanned in a fortnight, and the results were rather better than with oak bark.

J. Paessler (*Collegium*, vol. 89, p. 369) has studied the behaviour of extracts of myrabolans when kept under various conditions of strength and temperature.

A. G. Perkin (*Chem. Soc. Proc.*, 1904, vol. 20, p. 171) has continued his investigation of catechin, the colouring matter of Gambier, and has compared it with acacatechin obtained from the extract of the wood of *Acacia Catechu.*

Medicinal Products.—A short reference is made to the various examinations of the following products of a medicinal or toxic nature :—

Curcuma longa.—The composition of samples of turmeric from China, Pubna and Alleppi, has been published by A. E. Leach. (*Journ. Am. Chem. Soc.*, 1904, vol. 10, p. 1210.)

Cycas circinalis.—Van Dongen has isolated a toxic glucoside, pakoin, and crystals of phytosterin from the fruit (*Pharm. Zeit.*, vol. 48, p. 425)

Datura Stramonium seeds.—W. R. Dunstan found 0·26 per cent. of hyoscyamine in seeds from Busharh. Samples of seeds from Egypt and Europe are richer in this alkaloid.

Entada scandens.—L. Rosenthaler has examined the saponins in the seeds of this plant. (*Archiv der Pharm.*, vol. 241, p. 614.)

Gymnema sylvestris.—The leaves have been submitted to a chemical analysis by F. B. Power and F. Tutin (*Pharm. Journ.*, 1904, vol. 73, p. 234.). The authors isolated from the alcoholic extract a colourless, crystalline, laevorotatory modification of quercitol, hentriacontam, formic and butyric acids and resins. The gymnemic acid found by Hooper in 1888 was re-examined.

Gymnostachyum febrifugum.—The root of this plant, growing on the Western Coast, has been examined by Hooper (*Journ. Pharm.*, vol. 73, p. 4). It contains a bitter resinoid principle, a cholesterol, with small quantities of tannin and sugar.

Hyoscyamus muticus from Sind. W. R. Dunstan finds in the stems 0·36 per cent. and the leaves 0·38 per cent. of hyoscyamine. This yield is lower than that recorded for the Egyptian plant.

Psidium Guyava.—The leaves of the Guava tree contain resin, fat, tannin and essential oil; the latter yields eugenol. A. Altan (*Bull. de Pharm. de Bruxelles.*, vol. 48, p. 193.)

Rusot.—A medicinal preparation prepared from the root and stems of species of Barberry is made in Northern India. Samples have been found to yield from 4 to 8 per cent. of berberine. The drug has been described and examined by D. Hooper. (*Journ. As. Soc. Beng.*, vol. 73, pt. 2, p. 176.)

Punica Granatum.—E. Leger has devised a process for the estimation of alkaloids in pomegranate bark (*Journ. Pharm. Chem.*, 1904, vol. 19, p. 329).

Strychnos Nux-vomica.—H. W. and S. C. Gadd have studied the distribution of fat and strychnine in the seeds of nux vomica (*Journ. Pharm.*, vol. 73, p. 246). E. Leger has also described the alkaloidal assay of the seeds. (*Journ. de Pharm. et Chim.*, 1904, vol. 19, p. 479.)

During the year Dr. W. R. Boorsma of Buitenzorg, Java, has published No. 11 of *Pharmacologische Mitteilungen*, giving the results of the examination of plants of the natural orders Ternstrœmiaceæ, Guttiferæ, Rutaceæ, Rosaceæ, Compositæ, Myrsinaceæ and Apocynaceæ. These results are interesting from a phyto-chemical point of view.

Foods.—The chemical composition of the fruits of *Ficus bengalensis F. Cunia, F. glomerata, F. religiosa* and the seeds of *Shorea robusta*, all of which are consumed as human food, were analysed by Mr. Otto Reinherz. (*Agricultural Ledgers*, 1904, Nos. 4 and 5, pp. 25—32 and pp. 33—36.)

The composition and feeding value and the digestibility of a number of famine foods was determined by Drs. Noël-Paton and Crawford Dunlop at Edinburgh. The list included the seed of *Panicum colonum*,

P. javanicu and four unidentified species of the same order, *Eleusine ægyptiaca*, *Indigofera glandulosa*, *Coix Lachryma-Jobi*, the fruits and roots of *Nymphæa Lotus* and of *Cyperus bulbosus*, and the pollen of *Dregea volubilis*. The toxic action of the seed of Eleusine ægyptiaca and Nymphæa Lotus restrict somewhat the ration of these. Of those examined the best were P. colonum, a specimen going by the name Batterioo or Golio, the flower of Dregea volubilis, Coix Lachryma-Jobi, and Panicum javanicum. The roots of Scirpus grossus and Cyperus bulbosus provide poor food. (*Agricultural Ledger* 1904, No. 6, pp. 37-59.)

The composition of twenty-eight "pot herbs" has been determined by D. Hooper, some of them also after cooking. Many of them are characterised by a high proportion of proteids. (*Agricultural Ledger* 1904, No. 6, pp. 61-72.)

In the Indian Museum the seeds of Tanyin (*Pithecolobiun lobatum*) from Tenasserim were analysed among other food stuffs. The seeds were fairly nutritious and afforded when mixed with water a penetrating essential oil composed of a sulphur compound of allyl.

Cyanogenetic glucosides.—Mention was made in the last report (page 20) that Power and Gornall had detected a cyanogenetic glucoside in the seeds of *Gynocardia odorata*, obtained from India. It has been named gynocardin. Power and Lees have continued the investigation of the glucoside which, like other similar glucosides, is associated with an enzyme, and is hydrolysed by the latter. d-glucose and hydrogen cyanide were obtained as products of the hydrolysis together with a third substance not yet identified. Gynocardin is also hydrolysed by boiling dilute hydrochloric acid, and hot barium hydroxide reacts with it, ammonia and barium gynocardinate being formed. (*Trans. Chem. Soc.*, Vol. 87, p. 349-57.)

Coffee.—The valuation of raw coffee depends at present on a "liquor" test. Dr. Lehmann has determined the specific gravity of a series of samples with a view to comparing this with the market value of the berry. To a certain extent coincidence is noticeable, but divergencies also occur. (*Vide Anuual Reports of the Agricultural Chemist, Department of Agriculture, Mysore*, 1904, p. 9, and 1905, p. 17.)

For an account of the numerous experiments in sugarcane cultivation in Java reference should be made to "Verslag over 1904 van het Prœfstation voor Sukerriat in West Java Kagok te Pakatongan."

Country Spirit.—A most important measure in connection with Indian excise was inaugurated last November. It was considered desirable to make a thorough enquiry into the properties of country spirit which, under the present system of manufacture, is alleged to be harmful. Major C. H. Bedford, D. Sc., I.M.S., has accordingly been placed on special duty under the Finance Department, Government of India, with head-quarters at Kasauli, Punjab, and with the help of two chemical assistants recruited in London. The investigation embraces the chemical composition of the liquor, physiological action of the by-products, and means for improving the manufacture of the various classes of spirituous liquors made in India; and also to devise excise tests by means of which their quality can be effectually controlled. A comparative study of the existing methods of spirit analysis, with special reference to the quantitative estimation of by-products, was first carried out, the samples being either those of ordinary manufacture or prepared in the laboratory and containing known proportions of by-products. Much work was done on the question of freeing spirits from certain of the more noxious constituents. The question of obscuration of alcoholic strength was thoroughly investigated, and a simple means devised of examining distillery spirit for obscuration. Other scientific enquiries on Excise questions of importance have also been investigated, such as the means of distinguishing licit from illicit spirits; the best means of denaturing "industrial spirits;" "shrinkage" wastage in blending; and "breaking down" of liquors.

H. H. Mann has contributed a paper to the Society of Public Analysts, London (*Analyst*, 1904, No. 29 p. 149) on "Potable spirits used by the native population of India." The percentage of fusel oil was extremely high in nearly all cases. Furfural was present in all the samples of spirit except one.

Mineral and inorganic.

Rain, Dew and Atmospheric Dust.—The amount of ammonia and nitrate in rain water at Dehra Dun and Cawnpore was determined

nder the supervision of Dr. Leather for a period of twelve months, and the quantity of such combined nitrogen amounted, respectively, to 3·6 and 3·2 lbs. per acre, quantities similar to those found in other countries. The amount of these constituents present in the dew at Cawnpore during last cold weather were similarly determined. The concentration of the ammonia and nitrate was found to be somewhat greater than in rain water, ranging up to one or two parts of nitrogen per 100,000; but the total quantity of dew is so small that the amount of this combined nitrogen per acre was only about one-tenth of a pound. Similarly collections of atmospheric dust were made at Cawnpore during the hot weather, but the quantity there is so small that it cannot have any appreciable effect on soils.

Drainage.—Records have been maintained at Cawnpore, by means of gauges precisely similar to those at Rothamsted, and up to the present the following are the principal results. It was estimated that of 43·3″ of rain which fell during the monsoon period, July to September 1904, 5″ was required to make up for the loss by evaporation during the dry period, 4″ ran off the surface during a very heavy fall on September the 9th, 25·7″ percolated and somewhat less than 9″ evaporated during the monsoon. The records show further that the amount of percolation is proportionate to the rainfall, and that the quantity of water lost by evaporation from the soil is greater during the monsoon than during the dry weather period; both results coinciding with the deductions obtained from the Rothamsted records.

The nitrate in the drainage water was also recorded, and unexpectedly large amounts were present. It is too early to discuss the figures, and although the drainage of the current year substantiates last year's deductions, the rainfall has been so small that but little drainage has been received; another year must elapse before the several deductions, which appeared tenable from the records of 1904, can be fully verified. The gauges were free from vegetation, and hence the quantity of water percolating and its accompanying nitrate were larger than would have occurred had the ground been occupied by growing plants. They were conditions of maximum loss.

Sewage.—The investigation into the rate at which sewage is hydrolysed in the septic tank, to which reference was made in the last year's

report, was continued at Manjri in August 1904. The results coincided with those obtained during the preceding cold weather, and show that the size of the tank required depends on the strength of the sewage as well as its quantity.

Iron in Natural Waters.—The determination of small quantities of iron, such as are met with in natural waters, was the subject of a communication to the Society of Chemical Industry by Dr. Leather. Such quantities of iron are usually too small to admit of being weighed. It was found that they could be measured as ferri-ferrocyanide (Prussian blue) or ferric thiocyanate in Lovibond's tintometer. In this manner quantities as small as one-hundredth part of one milligram in 20 c. c. of water can be estimated with considerable precision. (*Journ. Soc. Chem. Industry*, Vol. 24, pp. 385-7).

Dr. P. C. Roy, Presidency College, Calcutta, has contributed the following four papers to the Chemical Society, London.

Mercuric Nitrite and its Decomposition by Heat. (*Journ. Chem. Soc.*, Vol. 85, pp. 523-527).

The Sulphate and the Phosphate of the Dimercurammonium series. (*Journ. Chem. Soc.*, Vol. 87, p. 9).

Theory of the production of Mercurous Nitrite and of its conversion into various Mercury Nitrates. (*Journ. Chem. Soc.*, Vol. 87, pp. 171-177.)

The Nitrites of the Alkali metals and metals of the Alkaline Earths and their Decomposition by Heat. (*Journ. Chem. Soc.*, Vol. 87, p. 177-184.)

In the Indian Museum analyses were made of certain shell-limes in order to compare their composition with that of limestone, and to estimate their values for building and manurial purposes.

It is important to notice in conclusion that the year has been signalised by the completion of the Cordite Factory near Wellington, in the Nilgiri Hills, and the manufacture of an explosive material of satisfactory purity compared with the cordite manufactured in England.

ASTRONOMY.

BY

G. T. WALKER, M.A., Sc. D., F.R.S.

Meteorological Reporter to the Government of India and Director-General of Indian Observatories.

Solar Physics.—Research in solar physics is carried on under the direct control of the Government of India at Kodaikánal, the Director being Mr. Michie Smith. The chief instruments there are :—

(*a*) A spectroheliograph recently made by the Cambridge Scientific Instrument Company. In this apparatus the image of the sun—made by a 12″ triple-achromatic lens of 20′ focus fed by an 18″ Foucault siderostat—and the camera are stationary, while the collimating and camera lenses, each of 5″ aperture and 6′ focal length, together with the prisms and slits, are moved on a rigid framework.

The spectroheliograph arrived and was erected in August last: it is carefully designed and well made, and the photographs obtained are extremely promising.

(*b*) Two 6″ refractors with one of which an Evershed spectroscope has been used since November, 1904.

These are used for visual examination of the sun and for spectroscopic study of spots and prominences.

(*c*) A spectrograph consisting of an 11″ polar siderostat with a 6″ Grubb lens and a 4″ grating. The details have been improved, but the apparatus has been out of use for a large part of the year owing to building operations. It will shortly be used for sun-spot spectra.

(*d*) A photoheliograph by Dallmeyer. With this a photograph of the sun is made daily when possible.

2. The routine work now includes photographs of the sun in ordinary and in mono-chromatic light, visual examination of sun-spots and feculæ, observations of widened and displaced lines in sun-spot spectra, and spectroscopic observations of prominences. A monthly article describing the solar activity is contributed to the "Monthly Weather Review," while for more technical purposes the publication of bulletins

of the observatory has been decided upon. Of these one was printed during the year 1904-05, and two have appeared since then.

There is also at Poona, under the Government of Bombay, the Takhtasingji Observatory, where research in solar physics is carried on by Mr. Naegamvala. The chief apparatus is:—

(*a*) a Foucault 12″ siderostat with an 8″ image lens and a spectroscope with a 1½″ Rowland grating. With these daily observations are made of the twelve most widened lines in sun-spot spectra in the region D—F: the results are forwarded to Sir Norman Lockyer;

(*b*) an equatorial refractor with a Cooke 6″ triple photovisual lens. This is provided with two 45° objective prisms, but has been dismounted during a large part of the year in order that alterations and additions might be effected;

(*c*) an equatorial reflector with a 20″ mirror by Common. This has also been dismounted for alterations.

At Dehra Dun, under the Survey of India, the photoheliograph has been in regular use, and photographs of the sun have been transmitted to Greenwich for measurement in the joint series with those of Greenwich and Mauritius.

METEOROLOGY.

BY

G. T. WALKER, M.A., Sc.D., F.R.S.

Meteorological Reporter to the Government of India and Director-General of Indian Observatories.

Study of the monsoon region.—Investigation has been carried on of the marine data for the northern Indian Ocean as extracted from logs, and of the pressure and temperature conditions in the countries bordering that ocean. The preparation of the series of daily charts extending southward to latitude 12° S and based on copies of logs made at Calcutta and Bombay was discontinued from 31st December 1904 in view of the extension of the area over which data are collected, and data are now coming in from Washington and Mauritius, as well as from Calcutta and Bombay, from ships whose voyages extend over an area extending from longitude 20°E. to 125° E.

and from latitude 25°N. to 50° S.; arrangements have also been made for the supply of copies of logs from London and Hamburg. As the observations of wind appear to be more reliable than those of pressure, a beginning has been made with the study of the connection between their abnormalities and those of Indian weather.

Meteorological data for the chief stations in south and central Asia, east and south Africa, and Australia have been collected, and the departures from normal of their monthly means have been tabulated up to date: these departures have been entered on a series of small charts for convenience in discussion, and have also been subjected to analysis with the view of finding causal relationships with Indian rainfall. Some relationships appear to have been established while others are merely foreshadowed: chief among the former is the prejudicial influence of very heavy rain in April and May at Zanzibar or the Seychelles, whether preceded by heavy snowfall or not, upon the subsequent Indian monsoon rainfall, especially on the Bombay side: among the latter may be quoted the surprising tendency of deficiency of pressure at Mauritius during June, July, August or September to be followed by *excess* of rainfall in India, and *vice versâ*.

Investigation of the upper air.—*Kites.*—Owing to delay in the arrival of materials it was not possible to start ascents until 27th August 1905, when Mr. J. H. Field went to Karachi with eight kites of the "box" pattern made at Simla and three Dines' meteorographs recording temperature, pressure and humidity. The winding gear was for hand power and contained several devices for avoiding the usual difficulties: both it and the kites proved successful and no accidents occurred. Eleven ascents in all were made and the greatest height reached was 4,700 feet with two kites in tandem and 10,300 feet of steel wire out.

The moisture-laden wind from the Arabian Sea was found to extend up to between 2,000 and 3,300 feet, with a humidity varying from 70 per cent. to saturation, and an approximately adiabatic temperature gradient. An additional ascent of 1,000 feet into the gentle current above this was only rendered possible by rapid hauling in of the wire, and a strong temperature inversion was found in this relatively dry stratum.

Balloons.—For ascertaining the nature of the upper air currents it has been decided to use free balloons and to make observations of the path with two theodolites at a distance of 2½ miles apart : as there is no chance of retrieving the balloons no meteorographs are employed. Some difficulty was found in securing a material that was impervious to hydrogen and light enough to reach great heights without adopting a larger size of balloon than was consistent with economy; and gutta percha tissue weighing 100 grains per square foot was finally adopted. In each of two ascents made in October a height of 25,000 feet was reached, and the velocity of the air at that height was on the 6th 30½ miles an hour in the direction 13° north of east, and on the 18th 35 miles an hour in the direction 17° south of east.

Daily Weather Work.—A beginning has been made with the preparation of files of small sized charts of typical depressions and storms for use in connection with the daily forecasting, so that in cases of uncertainty it may be possible to refer at once to previous cases of similar conditions. For subsequent verification and criticism full sized copies of the daily weather maps are being made, indicating as far as possible the character of the actual rainfall as given by the returns from the 2,500 rain-recording stations : these will materially increase mechanical facility in handling the records of the past and deducing practical maxims for future guidance.

Special researches.—Apparatus for measuring the electrical condition of the air has been set up at the Calcutta Observatory, and observations now form a part of the routine work. Professor Cunningham has also made a special tour in the Bay of Bengal just before the advent of the monsoon in order to ascertain whether special electrical conditions prevail at that time.

Publications.—In addition to the Daily Weather Reports published at Simla, Calcutta, Bombay and Madras, the Monthly Weather Reviews, the Annual Summary and various administrative pamphlets, the following memoirs have been published during the year 1904-05 in the series of Indian Meteorological Memoirs :—

(1) Discussion of monthly mean surface and underground temperatures deduced from observations taken at Lahore, Jaipur, Dehra Dun, Allahabad and Calcutta during the

years 1880-1901, by R. Ll. Jones, M.A., F.R.A.S., Meteorological Reporter to the Government of Madras.

(2) Normal monthly and annual means of temperature, pressure, wind, humidity, cloud, rainfall and number of rainy days of stations in India, etc., by Sir John Eliot, M.A., F.R.S., K.C.I.E., late Meteorological Reporter to the Government of India and Director-General of Indian Observatories.

(3) A preliminary investigation of the more important features of the meteorology of Southern Asia, the Indian Ocean and neighbouring countries during the period 1892-1902, by Sir John Eliot, M.A., F.R.S., K.C.I.E.

The printing of the meteorological and climatological atlas of India, which has been prepared by Sir John Eliot and is being published by Messrs. Bartholomew of Edinburgh, is nearly complete and the appearance of the work may shortly be expected.

During the past five years pilot charts showing the normal pressure, winds and currents for the Indian Ocean north of latitude 12° S. have been published and issued month by month to subscribers : the pressure and winds were based on the data collected in this office from 1893 to 1900. It is believed that an atlas containing the twelve monthly charts will be more useful than separate sheets of paper, and arrangements have been made for its publication : the normals on which the atlas is based have been brought up to date and charts, giving additional information, are being inserted.

TERRESTRIAL MAGNETISM.

BY

G. T. WALKER, M.A., Sc. D., F.R.S.

Meteorological Reporter of the Government to India and Director-General of Indian Observatories.

Magnetic Observatories.—*Colába (Bombay) and Alibág.*—An observatory had been erected at Alibág in order to receive the magnetic instruments whose transfer from Colába would shortly be rendered necessary by the institution at Bombay of electric tramways : happily

the new building for the self-registering instruments has proved extremely successful in the fundamental requirement of preserving constancy of temperature. A set of three Watson magnetographs was brought into use at Alibág in March 1904, and a comparison of the new and old sites, which is to last until 31st March 1906, was then begun : the magnet of the new horizontal force instrument showed at first some lack of constancy, but it has now settled down sufficiently and the records promise to be quite satisfactory. It appears from the traces made on quiet days that the diurnal oscillations are then precisely similar in amplitude and phase at the two places.

A special staff of two computers was appointed in December 1904 to assist in the tabulation and discussion of the magnetic records of 59 years at Colába, and this work is still in hand.

Dehra Dun, Kodaikánal, Barrackpore and Toungoo.—Of these observatories, which have been established as base stations in connection with the magnetic survey, the first two were started in 1902, the third in August 1903 and the last in December 1904 : they are all equipped with Watson autographic instruments for declination and horizontal intensity. A magnetograph for recording vertical force was erected at Dehra Dun in August 1905, and experiments for the elimination of the temperature co-efficient are now in progress : similar instruments will shortly be installed at the other three observatories.

The magnetographs at Dehra Dun, Kodaikánal and Barrackpore have behaved well throughout, apart from several interruptions at Kodaikánal due chiefly to fungoid growths which have appeared there several times. At Toungoo, as at Alibág, the magnet of the horizontal force magnetograph was found to be losing moment, and it was necessary to visit the observatory and "age" the magnet.

Magnetic Survey.—The preliminary survey of India for which sanction has been given is planned to involve :—

(*a*) Observations for declination, intensity and dip at about 1,100 stations, whose distance apart will be comparable with 35 or 40 miles, the "density" being one station to 1,300 square miles.

(*b*) Observations in successive years of the magnetic elements at 23 "repeat stations" in order to make possible the elimination of secular variation.

(*c*) Data from absolute and self-registering instruments at Colába and the four special base stations already mentioned.

A beginning was made with field work in November 1901 and the operations up to the end of the year 1902-03 have been described in previous reports : by that time 370 stations had been visited and 9 repeat stations established.

In the year 1903-04 observations were made by 5 detachments at 233 new stations, while 8 new repeat stations were instituted and comparative observations made at the 9 already in existence.

Some discrepancies with previous determinations were found when the moments of inertia of the field magnets were re-compared, and the original values were provisionally adhered to pending an investigation of the cause.

During the working season of the year 1904-05, four field detachments were employed and much marching had to be done. Observations were made at 206 new stations and 4 old repeat stations. Five new repeat stations were also started, but the season's work was considerably and unavoidably curtailed, and 13 repeat stations had to be omitted.

Much of the remaining work of the preliminary survey is in difficult country, and progress will be slower than it has been; but it is confidently expected that the work will be completed by four detachments in two more years.

The magnetometers used in the field have behaved uniformly well during the past year ; but some of the dip circles have given considerable trouble, in spite of having been put into thorough adjustment and working order at the beginning of the field season. In view of these difficulties and the approaching installation of vertical force magnetographs a small earth inductor, as made by Schulze of Potsdam, of which the average errors are much less than those of a dip circle, has been ordered for Dehra Dun and the purchase of three others is under consideration.

Major H. A. D. Fraser, R.E., who had been in charge of the magnetic party, was ordered home in March 1905, and his place has been taken by Captain R. H. Thomas, R.E. The former conveyed the two Indian

standard inertia bars to Kew, and it was found that both had lost weight : sanction has accordingly been asked for the purchase of a delicate balance in order that such changes may be detected and the need of a re-determination of the moment of inertia indicated.

The computation of the season's field work was begun in May and is now approaching completion: good progress has also been made with the tabulation and reduction of the results for 1904 of the base stations.

GEOLOGY.

BY

T. H. HOLLAND., F.G.S., F.R.S., A.R.C.S.
Director of the Geological Survey of India.

General Geology.—The work of extending the geological map over previously unsurveyed areas has been the main object of three parties—one in the Northern Shan States, another in Central India, and the third in the Central Provinces.

In addition to these surveys, exploratory work was conducted in the Persian Gulf and in the Andamans and Nicobar Islands.

The work in the Northern Shan States has been in progress for the past five years, operations being impeded seriously by the way in which the country is covered with thick jungle and a heavy crust of weathered products. Over considerable areas it has been impossible to map boundaries with any degree of certainty, but the collections of fossils that have been made show the existence of strata of Cambrian, Silurian, Devonian, Permo-Carboniferous, Jurassic and Cretaceous ages. The fossils are now being described by specialists in Europe, some of the results being already in the press for publication in the *Paleontologia Indica*.

The discovery of Productus-limestone fossils in the Northern Shan States adds another locality to those previously reported, thus assisting in mapping the boundary of the old Gondwana continent on which our most productive coal measures were formed. Productus-limestone fossils have long been known in the Salt Range, the Central Himalayas, and Kashmir; but during the past few years they have been discovered

also in the Southern and Northern Shan States, in north-east Assam, and this year in Arabia.

In addition to the stratigraphical work done in the Northern Shan States opportunity has occurred for the study of some interesting problems in physical geology. Two of these form the subjects of special papers published in the *Records* of the Geological Survey—the natural bridge of travertine, on which the railway viaduct at Gokteik is built, and the recent changes in the course of the Nam-tu river.

In Central India, the past season's work was mainly in Bhopal territory. The formations mapped consisted mainly of Vindhyan strata, Deccan Trap, and laterite patches. As all three formations are nearly horizontal, and separated from one another by denudation-intervals which produced irregular surfaces, the work of mapping has been slow and tedious in comparison with the few results obtained of general scientific interest.

In the Central Provinces the work of mapping was limited to the area covered by the eastern half of Atlas Sheet No. 72, the rock-formations studied being Archean granites and gneisses, interfolded bands of sub-metamorphics resembling the Dharwars, and outliers of Deccan Trap, with underlying Lameta beds.

During the course of survey work on the Manganese-ore deposits in the Central Provinces, opportunity occurred for a detailed petrological study of the associated gneisses and schists in the Nagpur and Chhindwara districts. The chief groups of rocks had been surveyed some years before, and the observations then made have now been supplemented by microscopic work for two papers published in the *Records* of the Geological Survey. The petrological results cover the Deccan Trap flows and the associated Lameta beds, with the underlying Archean formations, which include various forms of granites, granulites, gneisses, schists, calciphyres and cipolins, as well as the manganese-ores. Amongst the results obtained the most interesting are (1) the data which support the theory first advanced by Professor Judd with regard to the origin of similar calciphyres in the Ruby Mines district from pyroxene-gneisses and granulites; (2) the extensive silicification of the Lametas and the underlying Archean gneisses in the areas that were once covered by the Deccan lava-flows; (3) the mineralogical habits

of the calcites and dolomites; and (4) the great variety of new silicates in which manganese occurs as a prominent constituent, forming remarkably pleochroic forms of mica, pyroxene and amphibole.

The formations examined in the Persian Gulf and adjoining parts of Arabia and Persia include a small area of Archean schists in Omán, as well as beds in which siliceous limestones are prominent, including fossils ranging from Carboniferous to Triassic. From about Jurassic times onward a more complete geological history of the Gulf region is obtainable. At the close of Jurassic times, or early in the Cretaceous, there was a great outpouring of basic igneous rock, in the form of huge sills and flows. At the beginning of the Cretaceous great folding and crushing movements took place, which folded-in these sills and flows among the older limestones, and produced the mountain ranges of Omán. In the ocean bed whose southern limit was defined by these upheaved older rocks were deposited the upper Cretaceous beds of Hippuritic limestone which cover such large areas in Persia and overlie the igneous rocks of Omán. Following closely upon these and, perhaps, extending into the eocene period occurred a great series of volcanic flows accompanied by the formation of thick beds of salt and gypsum. This volcanic area extended approximately over the space now occupied by the eastern and larger basin of the Persian Gulf proper. It seems likely that shallow water conditions prevailed here, and some of the lavas and tuffs of the Ormuz series were probably subaqueous. At the same time, or a little later, some of the Hippuritic limestone must have been undergoing denudation.

Succeeding this period of volcanic activity, that is to say in middle eocene times, occurred a depression of most of southern Persia, within which the eocene rocks were deposited. This was accompanied by an upheaval of the volcanic area of the Ormuz rocks into dry land, which formed a barrier separating the eocene rocks of Persia from those of of Bahreyn. It seems not unlikely that this land barrier continued through the upper eocene, oligocene, and miocene into the pliocene.

It is difficult to say what amount of unconformity there is between the latest of the Nummulitic limestones and the lowest beds of the Mekrán series, but in any case such movements as took place seem not to have tilted the Nummulitics appreciably. It is also certain that

the rocks of Mekrán age must have been laid down over much wider areas than they occupy at present, as outlying patches are found even in northern Persia, and very little of the Nummulitic area may have been dry land in miocene times. The southern limits of the Mekrán sea, on the other hand, seem never to have stretched much beyond the present Persian coast. Minor movements undoubtedly disturbed the sea floor and perhaps elevated the Mekrán coast and eastern Persia, before the deposition of the Bakhtiári grits in the pliocene. But it was subsequently to this that the tremendous earth movements occurred which folded and faulted Cretaceous and Tertiary rocks alike, and elevated the pliocene sea bottom to 9,000 feet above the present sea level, forming the present mountain system of Persia. The actual Persian Gulf seems to have been less disturbed, as shown by the almost horizontal strata of the Mekráns in Henjam and the gently rolling eocene rocks of Omán and Bahreyn. It is on the whole likely that denudation continued over this area, and the carving out of the topographical features to which the floor of the Persian Gulf and the Gulf of Omán owe their present contour was concluded. The limit of this land was doubtless determined by the steep submarine cliff which runs along the Mekrán coast and then, cutting across the Gulf of Omán, runs parallel to the Arabian coast. Later, a widespread submergence took place, which buried fathoms deep the steep mountain valleys, river systems and sea cliffs that were being carved out for so many ages previously. To movements of this nature we owe the deeply-cut inlets of Massandim, and the islands dotting the Gulf, which are merely isolated peaks of the Ormuz volcanic series just rising above the surface of the water.

In still more recent times an elevatory movement must have been proceeding throughout the Persian Gulf. The flat ledges cut by the sea around Muscat and now raised above sea level, the recent littoral deposits of Omán and Persia as well as in the various islands, the sea terraces of Bahreyn, are all evidence of a widespread recent elevation of this area.

In the upper portion of the Gulf the deposits of the great rivers have contributed to this work of reclamation in an entirely different manner. The records of the past furnish us with abundant proofs of

how continuous and rapid has been the process by which the cities of antiquity have one by one retired inland from the littoral, and have been replaced by others on sites where once there existed flooded marshes or navigable water.

The principal result of interest obtained in the Andamans was the discovery of fossils in the Northern island in rocks whose age was previously unknown. The most important of these fossils are the foraminifera which indicate an eocene age. On Paget island the fossils included the characteristic *Nummulites budensis* of oligocene age.

Paleontology.—The paleontogical work done on behalf of the Geological Department during the year includes descriptions of Himalayan Triassic and Jurassic fossils by Professers Uhlig and Diener of Vienna; Cambrian, Silurian and Mesozoic fossils from the Northern Shan States by Miss M. Healey of Oxford and Mr. Cowper Reed of Cambridge; and the Nummulites of the Sind Tertiary formations by Mr. E. Vredenburg. The results in all cases are in the press for publication as new parts of the *Paleontologia Indica*. Mr. R. B. Newton of the British Museum has also published an account in the *Geological Magazine* of some pliocene fossils obtained from a number of concretionary boulders collected on the Mekrán coast.

Physical Geology.—The discovery of pleistocene vertebrate fossils in the alluvium of the Upper Godávari valley, referred to in the last Annual Report, has led to a study of the distribution of these pleistocene gravels in the river-valleys of the Peninsula and consequently of the changes of level which they indicate. One of the most interesting of these results is the evidence of a warping of the Peninsular mass along an anticlinal axis running N.N.E.—S.S.W. through Buldána in Berar and near Sehore in Bhopál. The pleistocene deposits of the Upper Godávari, which flows eastwards, and the lower Tápti, which flows westwards, lie to the west of this axis, whilst those of the Purna, which joins the Tápti, and the extensive deposits in the Narbada lie to the east of the hypothetical axis. Whilst there is no proof that lakes were formed, the alteration in the slopes of the valleys, due to this bending of the crust, changed the erosive tracts of the rivers into areas of temporary deposition with the resulting accumulations of alluvium that have since been eroded but not entirely removed.

Since the last report was issued the Government of India have sanctioned the organization of work for the determination of the silt carried down by the larger Indian rivers. A Geological Survey officer has commenced operations at two points on the Indus river for which careful gauge readings recorded for over 50 years give an accurate estimate of the water discharge, and it is proposed later to take up work on the Kistna, for which careful estimates have been made for the water discharge over the Bezwáda anicut.

Seismology.—The destructive earthquake which devastated a large area in the Punjab Himalayas on the 4th April 1905 has been made the subject of special study by the Geological Survey. Beginning at an early hour of the morning, when many people were still asleep, the more violent phases of the shock dealt summary destruction to life and property in the neighbourhood of the Kángra valley and Dharmsàla; accomplished very great damage and caused considerable loss of life in the hilly tracts of Mandi State and Kulu; did serious damage to Dehra Dun, Mussoorie, Chakráta and other towns in the vicinity; and slight damage to the large towns of Lahore, Amritsar, Jullundur, Saharanpur and others similarly placed with reference to the centre. Outside these points again, in ever widening closed curves, the effects of the earthquake were felt with continually diminishing intensity, until the limits of its appreciation by the unaided senses coincided roughly with part of an ellipse passing through the following localities—Quetta, Surat, Ellichpur, False Point and Lakhimpur. This curve, if continued, passes into the little-known and unreported-on regions of the higher Himalaya and Tibet; but it may be trusted to represent approximately the limit of sensible appreciability in that direction also, and to include a total area of about 1,625,000 square miles. Finally, outside these points (save for a few doubtful observations from isolated places), the record of the now greatly reduced vibrations is instrumental alone, but at the same time very complete. Not only did the seismological stations of India and the Far East—including those of Bombay, Kodaikánal, Calcutta, Batavia, New Zealand and Japan- automatically register the earthquake, but so also did those of Europe and America, the records being unmistakably those of a very powerful shock. The earthquake

must therefore be regarded as a notable one in the seismological history of the present and just concluded centuries, and, inasmuch as 20,000 human beings are estimated to have perished by it it must also be ranked as one of the most disastrous of modern times.

Owing to the interruption of communications, it was not until the 6th of April that the full significance and magnitude of the shock became generally known in India, and steps could be taken for the proper scientific investigation of it. By that date, however, telegraphic warnings were issued by the Director of the Geological Survey to all District Engineers, Meteorological Observers, Telegraph Masters, Railway officials and others through their respective Departments, to record in writing the exact time and other details of the shock. These were followed by letters sent to the principal newspapers inviting volunteers all over India to answer a formulated set of questions, and to help in other ways by furnishing exact data. Question-forms were also despatched to all the provinces, as well as to Political Officers and Residents of Native States. For the personal gathering of detailed observations of the effects of the earthquake in the more seriously disturbed area four officers of the Geological Survey were specially deputed within ten days of the catastrophe.

All reports gathered from places near the epicentre agree as to the suddenness of the shock, and the absence of a noticeable crescendo. The silent testimony of the long death-roll is sufficiently convincing of the rapid development of the shock, and the absence of any reasonably prolonged warnings conveyed by the preliminary tremors. That such preliminary tremors occurred is, however, clear from the accounts of survivors in the Kángra valley and neighbourhood, as well as at more distant points. In some cases in Dharmsála these preliminary warnings are stated to have enabled persons to leave their dwellings just in time. Although 135 perished in the big Gurkha barracks, such tremors are nevertheless implied by the fact that scarcely any of the victims were found killed in their beds. One account from McLeodganj bazar states that these first effects were of the "nature of tremulous vibrations and were likened to the rustling of leaves in the wind." In Dehra Dun, also, minor preliminary vibrations are recorded which enabled those who were awake to reach the door. In Mussoorie, according to an eye

witness, preliminary tremors lasted from 15 to 20 seconds; and the same were noticed in Landour by several people. In Lahore preliminary shocks with intervals appear to have lasted for about 11 seconds before the arrival of the main shock.

A common description of the main destructive oscillatory movement applicable to the Kángra valley and Dharmsála shows that it consisted of a violent horizontal shock from north to south, followed by an equally violent counter-shock from the opposite direction. A few observers noticed a third shock like a "downward" sinking. There is a preponderance of evidence in favour of the second shock being slightly the more violent, or at least the more destructive, of the two inasmuch as it was during it that " everything collapsed."

The distribution of the isoseismal lines, which have been mapped on the evidence of an abundance of independent reports from evenly distributed localities within the affected area, show that there was a main focus aligned parallel to the folded Tertiary rocks with a steep pitch to the E. S. E. in the Kángra area, and a subsidiary focus parallel to the first under the Tertiary mass in the Dehra Dun area. The depth of the Kángra focus was from about 18 to about 30 miles, with a pitch to the E. S. E. of about 13°. In both areas the geological map shows a noteworthy inbaying of the Sub-Himálayan Tertiary belt, and as the folding and fold-faulting of this tract, which has gone on since early Tertiary times, tends to straighten out the mountain foot into an uniform curve—the southerly convex curve of the Himálayan arc of folds—areas like those of Kángra and Dehra Dun, which show marked irregularities, are in a condition of strain, and are thus favourable to the development of faults, with the earthquakes that often accompany such rock-fractures.

With regard to the surface effects of the earthquake the following points were noticed:—

(1) All the surface valley deposits of alluvium, sand, gravel and boulders appear to have been proportionately more heterogeneously shaken than solid rock.

(2) Of rock, the soft Tertiary sandstones have been thrown into more destructive vibrations than the older and more compacted strata.

(3) Narrow ridges with free ends (spurs) have been very much more shaken than broad areas and the flat hollows between the spurs.

(4) In the case of the more distant vibrations and tremors, the great alluvial tracts, the flat-lying Vindhyans and the Deccan trap areas with cotton soil, have rendered such weak vibrations apparent, whilst the ancient and steeply dipping Aravālis have resisted the shocks in a very noticeable way. As a consequence there occurs an isolated area round about Udaipur, Dungarpur, Purtábgarh, etc., from which no accounts of any shock have reached us. It is interesting to note that this area was similarly barren of results in the 1897 earthquake, although the shock was recorded both east and west of it.

From observations made with regard to the overturn of pillars near Kángra, the acceleration of the wave particle at that locality was near 13 feet per second, with an amplitude of about 9¾ inches. The time of occurrence of the main shock in the Kángra area was 6h. 9m. (Madras time). The larger waves reached the seismographs at Colába near Bombay and at Alipur near Calcutta in exactly the same time, namely, 480 seconds, and as both places are just 950 miles from the main epicentre, the rate of transmission in both directions was 1·98 miles per second. The record obtained at the Kodaikánal observatory in South India showed that the same waves took 768 seconds to travel 1,497 miles. Taken along the arc this indicates a speed of 1·95 miles per second. The instruments at Tokio and other places in Japan registered a time which indicated an arcual velocity of 2·05 miles (3·3 kilometres) per second.

Steps have been taken to obtain a record of the numerous after-shocks which were felt and still continue in the meizoseismal area.

Since the Kángra earthquake occurred arrangements have been sanctioned by Government for the installation of seismological instruments in the Himálayan region. The instruments previously maintained in India were three Milne seismographs at Alipur, Colába and Kodaikánal, besides simple seismoscopes in Assam and Kashmir. An Omori-Ewing instrument, kindly lent by Professor F. Omori, was

erected during June at Simla in the office of the Meteorological Reporter, for the registration of distant and small shocks, and the purchase of new instruments, for the registration at Simla of macro-seismic as well as microseismic disturbances, has now been sanctioned by Government.

Economic Mineralogy.—There has been satisfactory progress made during the past year in mineral developments in India. The local value of the minerals raised, for which trustworthy returns are available, rose from £4,981,677 in 1903 to £5,338,096 in 1904, whilst a still greater increase was shown in the activity in prospecting, for which the licenses granted increased by over 50 per cent. Amongst the minerals which have created new interests are the gold-bearing-reefs of the southern Bombay Presidency and the alluvial deposits of the Burma rivers, for which encouraging prospecting results have been obtained; the chromite deposits in Baluchistan, where actual mining operations have commenced, and the iron-ore deposits of Raipur and Mayurbhanj, for the development of which a project is now being developed with a view to the erection of large iron and steel works at Sini on the Bengal-Nagpur Railway.

The *Records* of the Geological Survey published early in the year included a Review of Mineral Production for the previous six years, being the first of a series of reviews which are to be issued in the future for quinquennial periods.

During the past year, the survey of the known manganese-ore deposits was completed, and an account of the results is now in course of preparation for publication as a special memoir. The survey shows the existence of ore in quantities sufficient to meet the large export trade in the richest varieties for many years to come, and of practically unlimited quantities of lower grade which, at present prices, would not pay for the high transport charges to Europe and America, but would be available for the requirements of steel manufacturers in India. In the course of the survey, valuable data were obtained with regard to the geological relationships of the ore-bodies, and a number of new varieties of minerals were discovered.

Several additions have been made to the instances of aluminous laterites (bauxites) previously reported in Central India, Central Provinces

and in the Dharwar district. An account of the occurrences that may be regarded as reasonable "prospecting propositions" was published in part 2 of the current volume (XXXII) of the *Records of the Geological Survey*, in which the economic possibilities and limitations of these bauxite deposits was briefly discussed for the assistance of those who wish to undertake the enterprise of their development. Several concessions have been already taken up in the Central Provinces under prospecting licenses with a view to testing the value of the deposits. Arrangements are also well advanced for the introduction of bye-product recovery ovens for coke-manufacture with a view to the production, in the first instance, of sulphate of ammonia and tar, which have hitherto been lost in the primitive methods followed of coking in open ovens. With the establishment of large iron and steel works, there will naturally be an increased demand for coke, and a consequent increase in the output of bye-products requiring sulphuric acid. Arrangements have consequently been made by the Geological Survey Department for a thorough examination by diamond-drilling of the copper-sulphide deposits, known to occur at intervals along a band stretching across the Singhbhum district near Sini, where it is proposed to erect coking plant in connection with the projected iron and steel works.

A survey has been made of two bands of Dharwar rocks in South India, in which gold prospecting and mining have recently been undertaken. One of these is the so-called Maski band in which the Hutti mines are now being worked with a rapidly increasing output of gold; the other is the Gadag band further west in the Gadag taluk of the Dharwar district, where attempts are being made to open up and develop the ancient native workings which have honey-combed the auriferous quartz reefs to depths of at least 300 feet. Attention was directed by the Geological Survey to the promising characters of these occurrences in 1874, and though so long left neglected, the reports then published were adopted as the guide of the pioneer prospectors in 1900, whose work resulted subsequently in the organization of systematic mining operations.

The report, recently made of this area, is now in the press for publication in the *Records* of the Geological Survey, and gives a detailed account of the country rocks and reefs, the remains of ancient

mining operations, the prospects in alluvial and reef-gold and the subsidiary conditions affecting their exploitation.

In the Gadag band, the white auriferous quartz-veins occur in soft argillties, thus differing from the ocurrences in the Nizam's Dominions and the better-known case of Kolar in Mysore, where the gold is obtained from the blue quartz-veins lying in hornblende-schists. The occurrence is thus different from what might be expected from the Kolar analogy; but it adds weight to the conclusion that no general rules can ever be framed as a guide for the occurrences of gold in untested areas; each field must be studied for the discovery of its special peculiarities, and the determination of the existence of payable gold is always a matter of simple observation from practical tests, not of deduction from general principles.

In the course of surveying the previously known coal-fields of Namma and Lashio in the Northern Shan States, the Geological Survey party discovered two new fields, one near Mansang (lat. 22° 26′; long. 97° 57′), and the other near Manse-le (22° 40′; 98° 16′). All four fields form isolated basins lying on the plateau limestone of probably Paleozoic age, and consist of beds of sand, shale and coal of probably pliocene age.

In the Lashio field, the so-called coal is lignitic in character with large quantities of moisture and sometimes with a considerable amount of ash, resulting in a fuel of low grade which can only be of local value on the railways after briquetting. The lignitic coal in the Namma field is slightly better in quality, but still unfit in its raw state for use in locomotives. The most important seam in the field lies east of Namma village, where, for a proved distance of 2,400 feet, it varies in thickness from 7 to 17 feet. In the Mansang field 4½ feet was the greatest thickness observed in any seam, whilst in the Manse-le field the thickest seam was 4 feet in thickness. Full descriptions of these fields with a discussion of their possible economic value will be published in a forthcoming part of the *Records* of the Geological Survey.

GEODESY

BY

LIEUT.-COLONEL S. G. BURRARD, R.E., F.R.S.
Superintendent of Trigonometrical Surveys.

The geodetic operations, which are now in progress in India, may be classified as follows :—

(i) Principal Triangulation.
(ii) Levelling Operations.
(iii) Astronomical Operations.
(iv) Pendulum Operations.
(v) Tidal Operations.

Though these several operations can best be described separately, they are parts of one whole, and they mutually support and supplement one another.

Principal Triangulation.—In 1904 the officer in charge of the topographical survey of Baluchistan asked that a series of Principal Triangulation might be carried westwards from the Indus along the parallel of 29°. Surveys and reconnaissances based on detached triangulations had been previously made in different parts of Baluchistan, and an accurate trunk series was now required to tie them together. To comply with this request the triangulation party of the survey of India was transferred from Eastern Burma and the completion of the Principal Triangulation of Burma has been postponed for the present.

The parallel of 29° traverses a wider extent of land than any other parallel of latitude. If physical difficulties were the only obstacles to geodetic work, it would be possible now to measure on the earth an arc of parallel embracing 130° of longitude, and stretching from Sanghai to Morocco. Of this arc the Indian triangulation from Burma to Baluchistan has already measured 34°.

During the winter of 1904-05 work was started near Kalat, and a double chain of triangles was carried 150 miles to the westward. This chain will be extended during the next few months to the east and connected with the great series of the Indus.

The primary objects of a fundamental triangulation are to determine accurately the relative positions of the *extreme* points in a survey, and to prevent any *accumulations* of error in the area under survey. In Baluchistan therefore the new triangles are being made as large and as few as possible. Two advantages ensue from this policy: (1) the positions of points can be fixed with the greatest accuracy, for every intermediate station in a chain is a source of additional error: (ii) the Principal Triangulation becomes cheaper and advances more quickly than secondary series of small triangles.

It is beginning, however, to be recognised that heights when determined over long distances are less reliable, being more adversely affected by the refraction of the atmosphere, than those obtained from short. But this fact is not a sufficient reason for replacing large by small triangles: the gain resulting from a reduction in size is not worth the sacrifice. The problem of refraction is a difficult one, and it may even be found necessary for its solution to have different programmes for horizontal and vertical observations. When the relative *horizontal* positions of two distant points are being determined, a loss of accuracy is introduced with every intermediate station: when the relative *heights* of the same two points are being measured, a similar loss of accuracy ensues, but in the latter case it may be more than compensated by the reduced effects of refraction, whereas in the former there is no compensation.

On April 4th, 1905, the Punjab Himalayas were severely shaken by an earthquake. A chain of trigonometrical stations, one of the permanent and fundamental chains of the survey, rests on the outer ranges of hills and the possibility that some of the markstones have been displaced from their original geographical positions has to be considered.

To those who are interested in the preservation of these marks for the use of the future the frequent recurrence of earthquakes in Northern India must necessarily cause uneasiness, but investigation shows that there are no real grounds for despair. Before we can accept the retrograde view that accurate triangulation is useless, we must have definite evidence of the actual effects of earthquakes: at present our ideas of the movements caused by earthquakes are based on no complete proof.

The stations on the hills round Dehra Dun have perhaps a special geodetic value in that they form the northern terminus of the arc of meridian, which Colonel Everest measured from Cape Comorin to the Himalayas. Two years ago Everest's arc was extended northwards into the mountains over a distance of 35 miles, and that it may eventually connect with a Russian arc in Siberia and reach the shores of the Arctic Ocean is a reasonable expectation.

It was therefore important that we should determine whether the terminal stations as fixed by Everest had suffered horizontal displacement from the earthquake, and as this could be done near Dehra Dun without expense, several horizontal angles, which had been measured before, were re-observed last summer. Owing partly to the heat and the haze the revisionary observations were not of the highest order of accuracy; and we are consequently unable to tell whether horizontal movements of six inches or less have taken place or not. A comparison of the results however shows (firstly) that no relative displacement of 8 inches has probably occurred near Dehra Dun, and (secondly) that no relative displacement of 12 inches can have occurred.

Our revisionary work was necessarily local, and we had to be content with determining the extent of relative displacement within the locality tested. It would not have been possible without great expense to discover whether there had been any general movement of the Himalayas.

There were originally erected in India 3,706 trigonometrical stations of the Principal Triangulation:* in 1904 there were 3515 surviving. In spite of measures taken to ensure preservation the average rate of decrease has been of late about four stations per annum. The rivers of northern India, by their constant changes of course, have been very destructive; encroachments of the sea has washed stations away; the expansion of railways, canals and towns has necessitated the removal of others; and movements of sand in the desert have caused a few to be buried.

It is not possible to state the number of stations which have been displaced by earthquakes from their original positions; but seeing that

* On an average one station in every 450 square miles.

severe earthquakes have only occurred of late years in certain Sub-Himalayan regions, and having regard to the recent reassuring observations round Dehra Dun, I do not think it probable that the number which have suffered greater disturbances than 8 inches can exceed 40 : and an estimate of 40 errs on the side of pessimism.

After the great earthquake of 1897 we discovered horizontal displacements in Assam of 8 feet and more.* Mr. Oldham was of opinion that these were merely relative displacements in the small area tested, and that the absolute displacement of the whole area would have been found to be considerable if we had commenced our tests outside the disturbed region and worked inwards to the epicentre. But triangulation is a slow and costly operation, and it is not practicable to revise great lengths of it after every earthquake. The small local revisions carried out last summer to test the effects of the earthquake of 1905 were rendered possible by the fact that Dehra Dun is the head-quarters of the trigonometrical survey, and observations can be taken in its vicinity without expense or difficulty. The damage however done at Dehra Dun by the earthquake was small compared to that at Dharmsala, and our proof that the stations round Dehra Dun have not been relatively displaced by 8 inches is no proof that those near Dharmsala have remained equally undisturbed. If moreover we apply Mr. Oldham's argument to the case of Dehra Dun, we shall have to consider that the whole region may possibly have moved, although the relative positions of local marks have remained unaltered.

From a topographical point of view a displacement of 8 inches may be disregarded, but one of 10 feet is liable to cause inconvenience and error. If we suppose, for instance, that of the two trigonometrical stations of Hathidar and Lipiana, which are situated in Kangra 16 miles apart, one has been displaced *towards* the other by 10 feet, then the line joining the two would no longer form a suitable base either for the observation of distant snowpeaks, or for a series of minor triangulation for Tibet, although the disturbance might not embarrass plane-tablers surveying the immediate locality. If the displacement

* The revisions in Assam were made with a small instrument and the displacements were measured only to the nearest two feet: *vide* Report on the Trigonometrical Results of the Earthquake in Assam, 1898, paragraph 7.

had occurred in a direction *perpendicular* to the line joining the two stations, the accepted direction of this line would be in error by 25 seconds: and this is an error that would soon begin to inconvenience triangulators.

The Shillong Earthquake of 1897 rendered the positions of perhaps 15 stations uncertain, and the Dharmsala Earthquake of 1905 has possibly affected the same number. When in the future these stations come to be utilised, it will be necessary for observers to take the precaution of measuring the angles of two or three of the original triangles by way of a preliminary test.

We have long since had to introduce such a precaution into levelling operations: the heights of bench-marks when erected on alluvium are liable to vary with age, and when a new line of levels is being started from an old bench-mark it is not safe to accept its original value of height: it is always necessary to relevel to two or three of the old bench-marks in order to test for subsidence. Such a precaution has never hitherto been considered necessary in triangulation, because, although markstones may move vertically in the course of time, as a rule they maintain their horizontal positions. But there have been two severe earthquakes within eight years, and it is necessary now to recognise that in certain regions the positions of points will have to be accepted with greater caution in the future than in the past.

The displacement of the stations of the Principal Triangulation is but one aspect of the general problem of change which a survey has to face. The forms and positions of topographical features are always undergoing change. In certain cases the changes are so rapid that it is hardly possible to make a consistent survey at all: the Indus for instance is constantly eroding its banks, washing away survey and boundary marks, and altering its course perhaps by a mile or more. If the whole river were to be surveyed in one month, the map could be rightly headed "The course of the river Indus in January 1905," but to survey different portions at different times, as in practice we have to do, is to give a course to the river which it never actually pursued.

During the progress of the present survey of Sind many recently surveyed sheets have been rendered obsolete, almost before they have been published, by the opening of a new system of canals. And these

changes are going on everywhere from those that are so local and marked as to be perceptible to the most casual observer, to those that are so widespread and gradual as to require lengthy revisions of triangulation to reveal them.

The vertical angles of Everest's triangulation and his resulting values of height were very inaccurate. The *horizontal* angle between two distant stations can be accurately determined, because rays of light in passing through the atmosphere are not refracted laterally. But the measurement of the *vertical* angle between any point and the observer's horizon is always affected by atmospheric refraction.

Refraction varies with temperature and is least during the hottest part of the afternoon. When however refraction is least, the object to be observed is invariably blurred and unsteady: and when refraction is greatest and most harmful, the object becomes clear and definite.

In the days of Everest it was thought advisable to secure good clear signals for observation, and work during the afternoon was avoided because the signals were jumping and difficult to intersect. But heights by vertical angles were continually being found discordant, and discrepancies of 50 feet between two determinations of one height were common.

In 1850 Sir Andrew Waugh pointed out that if observers would do their best to intersect unsteady signals and would observe in the afternoons, their values of height would be found of greater accordance and accuracy than if they waited for the signals to be sharp and still. This reform of procedure proved most beneficial; errors of intersection due to the unsteadiness of the object have been found to be trivial compared to the errors caused by atmospheric refraction, and vertical angles are now always observed between 2 and 4 P.M.

But a large number of the Principal Trigonometrical heights of India were determined before 1850: they have never been revised and their inaccuracy is a continual source of trouble to topographers.

It must not be assumed that values of height observed by Waugh's method are wholly satisfactory: they are still affected somewhat by refraction, and can seldom be trusted within 6 or 7 feet.

Errors such as 6 or 7 feet are met with in India where stations have been mutually observed from one another, but in the case of

inaccessible snow-peaks the uncertainty is far greater: the air in these cases is rarefied and cold, the rays are of extreme length and traversing a white surface, and no reciprocal observation from the peak to the station in the plains is possible.

It is felt that endeavours should be made to reduce still further the evil effects of refraction, and an experimental investigation has been commenced at Dehra Dun. It is too early to say whether it will bear fruit, but the results of the Trigonometrical Survey are being compiled and classified in the hope that some useful information may be deduced.

In a country such as England, where the standard maps are on the $\frac{6 \text{ inches}}{1 \text{ mile}}$ and $\frac{25 \text{ inches}}{1 \text{ mile}}$ scales, it is economical to carry spirit-levelling everywhere; but in India, where the standard map is on the small scale of $\frac{1 \text{ inch}}{1 \text{ mile}}$, spirit-levelling is more suited at present to furnish a mathematical framework than to fill in interior details of relief. If then we could reduce the probable error of trigonometrical heights, a great service would be rendered to topography.

It will be understood from what has been said above that vertical displacements caused by an earthquake cannot be measured with any accuracy, if the original values of height have been determined by vertical angles. It happens however that the height of Mussoorie has been determined by spirit-levelling, and the effect of the recent earthquake can thus be ascertained within certain limits and will be discussed below.

Levelling Operations.—India has been intersected by lines of spirit-levelling and numerous circuits have been formed, but the closing errors of the circuits have never yet been distributed. It is inconvenient to continue with the heights of our bench-marks in preliminary values, and endeavours have been made of recent years to accelerate the mathematical adjustment of the net. But before this is undertaken, a certain amount of additional fieldwork has still to be carried out; some of the levelling circuits are at present very large; some areas, of which the Punjab is one, have not as yet been enclosed; some tidal stations such as Chittagong and Porbandar, have not been connected with the net; and some of the old lines may have to be revised.

It was at one time proposed to postpone the simultaneous reduction of the level net until the Indian and Burman systems of levelling had been connected. Theoretically this course would have been correct, but we are anxious to obtain final values for our spirit-levelled heights at an early date; and in 1903 it was decided to adjust the Indian levelling first and to build that of Burma upon it.

In Europe and America great revisions of levelling are carried out in order to reduce the closing errors of circuits, but in India the neccessity of extending our levelling over new ground has always been so great that there have been no opportunities for revision. The amount of revision that will now be necessary, before the adjustment is carried out, depends upon the results furnished in the early stages of revision and cannot be exactly stated beforehand. There has been only one serious error brought to light in India, and that is the discrepancy of 3 feet on the line between Bombay and Madras. If we are to accept the results of the levelling over that line the mean sea level at Madras must be 3 feet higher than that at Bombay: there is n reason to suppose that the sea level at either place is permanently affected by currents or winds, and we have no alternative but to assume that the discrepancy of 3 feet is an accumulation of error in the levelling observations. The length of the line is 796 miles, and the error accumulated is at the rate of 0·004 foot per mile. The Ordnance Survey allows an error of 0·01 foot per mile over short secondary lines, but as the accumulation of error over long primary lines should increase with the square root of the distance, the discrepancy at Madras is too large to be passed. It is now believed that the error must have been generated in the 200 miles between Gooty and Gulburga, and it is proposed to revise this section at an early date: if the error can be located, no further revision between Bombay and Madras will be needed.

During the winter of 1904-05 the levelling detachment of the Survey was employed in carrying a line of levels along the east bank of the Indus in Sind. The detachment returned to Dehra Dun in May and, under ordinary circumstances, would have been employed at once in reducing their fieldwork and compiling their results.

But on April 4th, 1905, Dehra Dun and Mussooree had been shaken

by the earthquake, and the levelling detachment was accordingly directed to relevel the line connecting the two places. This short line had been levelled over during the previous year, in order to furnish us with a means of testing the influence of atmospheric refraction on vertical angles observed between the hills and the plains.

In May 1904 the trigonometrical station at Mussooree was found by levelling to be 4,706 feet 10 inches higher than the station near the Survey Office at Dehra Dun. In May 1905 the difference of height was found to be 4706 feet 4½ inches. It would therefore appear that the Mussooree range has subsided 5½ inches with regard to Dehra Dun.

When the results were first tabulated, it was perceived that the amount of subsidence increased gradually as the levellers ascended the range. This gave rise to a suspicion that the lengths of the levelling staves may have been in error.

During the first 6 miles the ascent is 694 feet or 116 feet per mile, and in the last 12 miles it is 4,013 feet, or 334 feet per mile. A levelling staff being 10 feet long, and the difference of height being 4,707 feet, there were contained in the total rise 471 lengths of staff. If then the 10 foot staves had been 0·001 foot too long, our unit of measurement would have been slightly in error, our measured heights would all have been given too small and the deficiency accumulated at Mussooree would have been 0·471 of a foot, or about 5½ inches.

Four different staves are however in daily use, and these are periodically compared in the field against a 10 foot steel standard and corrections for each deduced. An examination of the results of the comparisons showed that the apparent subsidence of Mussooree could not be attributed to errors in the adopted lengths of the four staves.

The steel standard, against which they were compared, was then suspected, and this was subjected to rigorous tests under comparing microscopes at Dehra Dun. Its length, as now determined, accorded with the value previously obtained, and it became clear that the observed change in the height of Mussooree above Dehra Dun between 1904 and 1905 could not be attributed to any error in the adopted length of the standard of reference.

During the process of levelling the level is always erected midway between two staves, and at each station the observer by reading the staves through the telescope deduces the *difference* in height between the two points on which the staves are standing. Under ordinary circumstances there is no reason to fear accumulation of error. But when the line followed is constantly rising, as between Dehra Dun and Mussooree, the rays of light from the telescope to the higher staff pass always nearer the ground and are more likely to be disturbed by radiation than the rays to the lower staff: this fact introduces an uncertainty, which continues to exist whether we work up or down the hill, and which we endeavour to minimise by stopping work during the heat of the day. We are not, it is true, discussing now the absolute value of the height of Mussooree. The levelling observations of both 1904 and 1905 were taken in the month of May under similar atmospheric conditions, and we are only attempting to account for the *difference* of $5\frac{1}{2}$ inches which appeared between the value obtained in May 1904 and that of May 1905. Nevertheless it has to be recognised that an uncertainty does exist: it was the examination of this question that really revealed how little was known of the degree of accuracy of a line of levels on a steep slope. It is at times extremely difficult to obtain a definite numerical idea of the probable and possible errors which are accumulating in a lengthy survey operation, but a knowledge of these errors is essential before we can discuss the meaning of an actual discrepancy observed. In the levelling operations carried over the plains and peninsula of India no error approaching $5\frac{1}{2}$ inches in 18 miles has been met with,* and if by further levelling in the coming cold months we reproduce the same value of height for Mussooree as was last obtained during the heat of May, we shall then perhaps be justified in assuming that no exceptional error has been accumulated during the work, and that the difference observed of $5\frac{1}{2}$ inches is due to a real change.

Astronomical Operations.—The Principal Triangulation becomes of service to topography from the date of observation, but it is not

* The great error between Bombay and Madras *may* have been partly generated in the steep ascent of the Ghauts on the Bombay-Poona section, but the weight of the evidence is against this view.

of geodetic use, until astronomical observations have been taken at certain of its stations.

The astronomical tests are required—

(1stly) to determine whether errors imperceptible in themselves are not tending to accumulate in long lengths of triangulation;

(2ndly) to show whether the triangulation is being projected upon a spheroid that conforms closely to the actual figure of the Earth.

(3rdly) to indicate the direction of gravity at the station of observation, and the inclination to the mathematical horizon assumed under the influence of gravity by the levels of the astronomical instrument.

Astronomical observations were originally introduced to provide a foundation of fixed points for topography, but they were found insufficiently accurate for the purpose, owing to the fact that the force of gravity does not always act in the direction of the normal to the Earth's mathematical surface. At first sight, then, it seems peculiar that the astronomical method, which had to be discarded in favour of the triangulation, should now be utilised to check the accuracy of the latter. The explanation of the apparent anomaly is that the error of astronomical work remains constant, whilst the error of triangulation accumulates with the distance travelled, and that although the true distance and direction of Lucknow from Agra may be more accurately determined by triangulation, the distance and direction of Mandalay from Karachi can be best deduced from star observations.

Of recent years astronomical observations have been systematically taken with the object of determining the effects of the Himalaya mountains on the plumb-line. These observations brought to light the extraordinary facts that a flat, narrow zone of the Earth's crust, surrounding the Himalayas on the side of India, is extremely deficient in density, and that, to the immediate south, a second and parallel zone exists throughout which the density of the Earth's crust is abnormally great. From astronomical determinations alone we were not able to measure the exact deficiency or excess of matter underlying any parti-

cular station; but this will now be rendered possible by the pendulum observations.

In 1904 Captain Cowie, R.E., accompanied the Tibet Mission to Lhasa, and on his return was occupied for some weeks in compiling maps of Tibet. His topographical duties lasting till December, he was not able in 1904-05 to undertake a full astronomical programme. He was therefore directed to observe four latitudes in South Burma, which were required by the Director of the International Geodetic Association, and one azimuth at Chittagong, which was badly wanted for an investigation of the errors of triangulation.

A new determination of the figure of the Earth is now being made at Potsdam, and two of the Indian measurements are being utilised, *viz.*, the arc of meridian from Cape Comorin to Dehra Dun and the arc of parallel from Karachi to Moulmein. The Indian arc of parallel starts from a point near the telegraph office at Karachi and ends at a point near the old Artillery Mess at Moulmein: the distance in feet has been measured by triangulation and the difference of longitude has been determined astronomically.

The triangulation that has been carried west of Karachi into Baluchistan, and that which has been taken east of Moulmein, increase the measured length of the Indian arc, but they will not be of use in determinations of the Earth's dimensions and shape, until they have been supplemented by astronomical observations.

The arc between Karachi and Moulmein is now complete, Captain Cowie's observations in Burma having supplied the data that were wanting.

The latitude of Moulmein has been given as follows:—

As calculated through the triangulation.	16°	29′	54·62″
As observed from the stars by Captain Cowie.	16°	30′	2·97″
The astronomical value exceeds tne calculated value by			8·35″

This discrepancy of 8·35″ is due to three different causes: firstly, the deflection of gravity at Moulmein has rendered the astronomical value too large; secondly, the triangulation in its journey across India and Burma has slowly deviated southwards from the correct course, and has consequently placed Moulmein on the earth too far south in latitude by a few seconds; thirdly, the triangulation has been projected on too small a spheriod, and has been consequently extended over too large a proportion of the Earth's circumference.

It would have been better in many ways if we could have ended the arc of parallel in Upper Burma near the latitude of Karachi. Moulmein is so far south of Karachi that the arc becomes technically an oblique arc: when longitude observations have been taken in Upper Burma this defect will disappear.

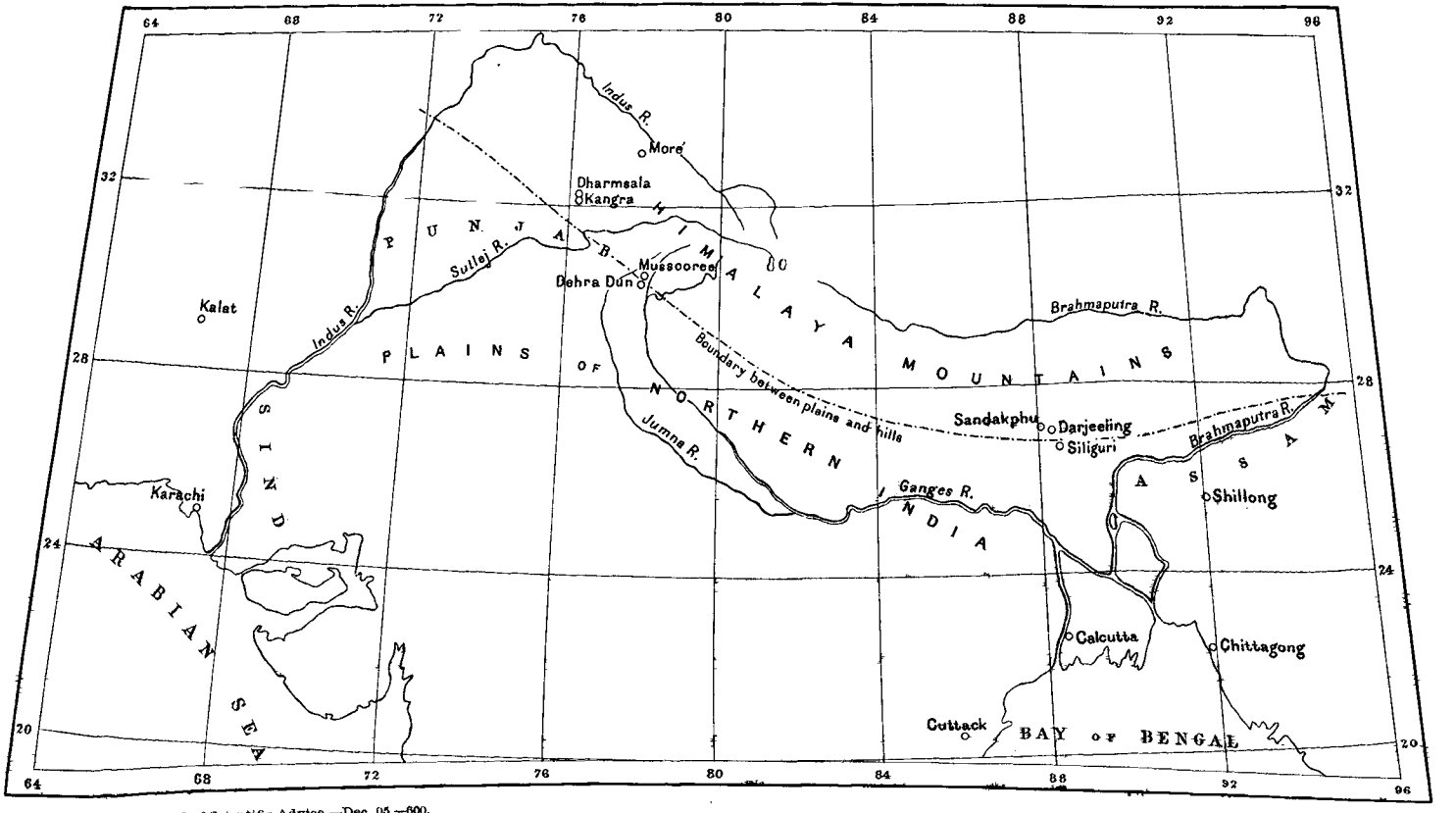
The azimuth which Captain Cowie observed near Chittagong formed part of a scheme for determining the error in direction which the triangulation has gradually accumulated throughout its length. An investigation of this error has been carried out at Dehra Dun during the summer of 1905, and the result will be shortly published in a volume on Geodesy.

The error of direction that has been generated in the Indian triangulation is always of the same kind: it is too small to be perceptible in short distances, but its accumulation seems to be steady and persistent. As we move from Karachi to Moulmein the triangulation tends to deviate to the south, and as we move from Peshawar to Cape Comorin it tends to deviate to the west: the deviation is always clockwise. When an error is very persistent, it is natural to suspect the existence of a definite cause, and we have endeavoured to examine, but so far without success, whether the deformations of the level surface in India would tend to throw the triangulation out of its course. All that can be said is that in this country the level surface does not conform to the spheroid, and that when we project the triangulation on the spheroid we meet with a persistent deviation; but whether this deviation is caused by the departures of the actual geoid from the assumed spheroid or whether by the accumulation of imperceptible errors of observation, we are not able to state.

CHART

illustrating the report on

PENDULUM OPERATIONS.



No. 457 E., Secy. Board of Scientific Advice.—Dec. 05.—600.

Litho., S. I. O., Calcutta.

Pendulum Operations.—The new pendulum apparatus arrived in India in 1903. It had been previously standardised at Greenwich and Kew, and Major Lenox-Conyngham's first task in India was to make a Base-Station of Dehra Dun by taking an exhaustive series of observations there. The result he finally obtained was as follows:—

	dynes
The force of gravity as observed at Dehra Dun	979·063
The normal force of gravity of any place situated in the latitude and at the elevation of Dehra Dun, according to Helmert's formula of 1884	979·186
Deficiency of the actual force below the normal	0·123

Between thirty and forty years ago Captain Basevi determined the force of gravity at a few stations in India of which Dehra Dun was one. When Major Lenox-Conyngham had completed his observations of 1903, he found that his result was considerably larger than Basevi's, and he proceeded in consequence to visit three other of Basevi's stations At each of these he met with a similar disagreement, his value always exceeding Basevi's. Professor Helmert, Director of the International Geodetic Association, had predicted that these differences would appear, and had given his reasons for believing that all Basevi's values were too small. The deficiencies in the latter are due to the fact that in Basevi's days there were no means of measuring or allowing for the swing of the pendulum's stand. When a pendulum hanging from a stand is set in motion, the friction at the points of suspension causes the stand to swing also. In former years observers endeavoured to remedy this evil by making their stands heavy and rigid, but it is now known that such expedients are ineffectual: masonry pillars and iron frames are equally liable to be set swinging, if an oscillating pendulum is in contact with them. By a recent invention it is possible to measure the oscillations of the stand and to allow for them in calculating the true time of observation of a pendulum.

The oscillation of the stand and pillar has the effect of retarding the vibrations of the suspended pendulum, and the intensity of the force of gravity being directly deducible from the observed time of

vibration is given too small. Thus it has come about that the observations of 1904 have shown those of 1866 to be incorrect.

The pendulum station of the old series which attracted most attention was that of Moré. This station situated on a plateau in the Western Himalayas at an elevation of 15,400 feet was included in the original programme at the request of the late Sir George Stokes. Basevi's observations indicated that at Moré the actual intensity of the force of gravity was 0·518 in defect of the value which geodesists had predicted from theory.

This extraordinary result could only be explained on the hypothesis that there was a deficiency of matter underlying Moré equivalent to 14,700 feet of the mountain mass. The visible excess of rock standing above the sea level at Moré being 15,400 feet, and the hidden deficiency being equivalent to 14,700 feet, the actual excess of mass in the Earth's crust under this high Himalayan plateau was according to Basevi's result only 700 feet.

It was partly owing to this observation that the Himalayas were supposed to be "compensated," and that the idea was formed that the great masses which we see towering above the horizon are more apparent than real. Archdeacon Pratt, whose mathematical knowledge was for so many years of service to the Survey of India, was the author of the celebrated theory that the amount of matter in all parts of the Earth's crust is the same, or, to use his own words, "that in the land "portions of the Earth's surface there is a deficiency of matter below the "sea level approximately equal to the amount of matter above it; and "that below ocean beds there is an excess of matter approximately equal "to the deficiency of matter in the ocean as compared with rocks."

Whether this theory will be generally confirmed by future pendulum observations it is too early to say; but recent investigations in India, both of the plumb-line and the pendulum, have shown that the original data on which it was based are untrustworthy, and that it is certainly not true of every mountain locality.

Before Basevi left Dehra Dun for Moré he discarded the heavy stand which he had previously employed, and substituted a lighter one of his own design. The swing of the latter, it is thought, must have been more serious than that of the former, and his result at Moré is

consequently regarded as more affected by error than that at Dehra Dun.

The defect of 0·123 in the force of gravity at Dehra Dun (which has now, we believe, been correctly determined by Lenox-Conyngham) corresponds to a deficiency in the subjacent strata equivalent to 3,500 feet of Himalayan rock: that is to say, if the crust of the earth were made homogeneous, Dehra Dun instead of being at a height of 2,200 feet above sea level would be 1,300 feet below it.

In 1904-05 Lenox-Conyngham took pendulum observations along a line extending from Cuttack in Orissa across the Ganges Valley to Darjeeling and the hills to the north.* He again found a deep deficiency at the foot of the Himalayas. His pendulum station at Siliguri is similar to that of Dehra Dun in being within a few miles of the foot of the hills. There is however this difference that the height of Siliguri above sea level is only 400 feet.

The theoretical and observed values of gravity were here found to be

The normal or theoretical force	979·049
The force of gravity as observed at Siliguri . . .	978·918
Deficiency of the actual force below the normal . .	0·131

This deficiency is even larger than that at Dehra Dun: it indicates that 3,700 feet of rock are absent from the crust at Siliguri, so that in an homogeneous section Siliguri would be situated 3,300 feet below sea level.

When we ascend from the plains to the outer hills, we find that the deficiencies of gravity tend to remain constant. At Mussooree, a station on the outer range of the Himalayas, the defect is similar to that at Dehra Dun but not quite so great; Mussooree is 6,900 feet above sea level, and this apparent excess of rock is compensated to the extent only of one-half.

The deficiency of gravity observed at Darjeeling in the hills north of Siliguri is 0·143. This last result differs but slightly from that obtained at Siliguri. Darjeeling is 7,000 feet higher than Siliguri, and this great excess of rock which rises so abruptly from the plains is not

* The values of the intensity of the force of gravity as determined in 1904-05 have not as yet been *finally* computed; the values given in this report must therefore be regarded as preliminary.

accompanied by any increase in the compensating deficiencies of the underlying strata.

The highest station visited by Major Lenox-Conyngham was Sandakphu, a point 35 miles from Darjeeling and 11,800 feet high: at this place gravity was found to be 0·149 in defect. This is a very different result from that obtained at Moré: it shows that the height of Sandakphu, would still be about 7,600 feet if all its underlying strata were condensed to normal density.

To the south of the great dip which has been found to exist along the foot of the mountains a considerable excess of mass has been discovered. From Siliguri southwards and from Dehra Dun southwards the deficiency in the force of gravity is observed slowly to disappear: 110 miles south of Siliguri, and 200 miles south of Dehra Dun the force of gravity is in excess.

The lines of pendulum stations that run south from Siliguri and Dehra Dun traverse the flat alluvium of the Ganges Valley, and there is nothing at the surface to indicate that the amount of matter in the crust is slowly increasing with the distance from the Himalayas.

It may be questioned whether the existence of alluvium tends in any way to decrease the intensity of the force of gravity: superficial alluvium is somewhat lighter than rock, but even at moderate depths the difference in their densities disappears. In the centre of the Ganges Valley, where the alluvium is presumably deepest, gravity is not in defect: it is along the northern edge of the alluvium that the maximum deficiencies of gravity have been discovered.

The number of results that are at present available for discussion are too few to justify any theory of Himalayan structure being formulated. All that we are now able to say is that the outer ranges of the Himalayas are partially but by no means completely compensated: that there is a great deficiency of matter at the foot of the hills, and that further south the deficiency disappears and gives place to an excess.

As to the constitution of the higher Himalayan ranges and plateaux we know nothing; nor have we any idea as to whether the lesser ranges of India, the Nilgiris, the Aravallis, the Vindhyas, and the Ghauts are compensated or not.

In February 1905 Professor Hecker, of Potsdam, joined Major Lenox-Conyngham's camp in Bengal: this officer had been deputed by the International Geodetic Association to observe the force of gravity over the great oceans. In the course of his work he reached Calcutta, and took the opportunity to compare his pendulums with those in use in India. Professor Hecker and Major Lenox-Conyngham observed their pendulums simultaneously on several days at Jalpaiguri: their co-operation has furnished us with the means of making a valuable comparison between the Indian pendulums and the Potsdam Standard.

Tidal Operations.—Throughout the past year tidal observations have been taken at the nine following observatories:—Aden; Karachi; Okha, in the Gulf of Cutch; Bombay (Apollo Bandar); Bombay (Prince's Dock); Madras; Kidderpore; Rangoon; Port Blair.

Of these Kidderpore and Rangoon are riverain stations, Okha is a gulf station, and the remainder are open-coast stations.

The total number of Indian tidal observatories which have been in operation at one time or another, and for which predictions are now annually calculated, is 42. Of these 33 have now been closed. It is not easy to tell whether our predictions for all the closed observatories are continuing to be satisfactory or not: at four ports only are predictions tested, and the method of testing is by means of graduated tide-poles which afford no reliable criterion. Of recent years the tests applied at Moulmein have not been considered sufficiently accurate and the re-opening of the observatory is under consideration. The times and heights of high and low water are largely influenced by the configuration of the coast, and at ports situated like Moulmein, near the mouths of large rivers, the movements of shoals interfere with accuracy of prediction if the data employed are old.

In former years the calculations of the predictions were postponed until the most recent observations were to hand, but under that system the published tide tables were frequently not ready in time: in 1903 the plan was adopted of calculating predictions three years in advance, and the data for the tide tables of 1907 have been already despatched to the Director of the National Physical Laboratory, Teddington, whilst those for 1908 are almost complete.

A tidal observatory was first erected at Okha, in the Gulf of Cutch, in 1874 at the instance of geologists, who desired to ascertain whether the land was subsiding or not. When sufficient observations had been taken to furnish a reliable value of mean sea level for a datum, the observatory was closed. It was re-opened in 1904, and will be again closed down when a further complete year's observations have been recorded.

A line of levels will then be carried from the observatory to some old bench-marks, erected at different distances from the coast, and the data thus obtained will be sufficient to determine whether the height of the land above mean sea level is different to what it was 30 years ago.

At the suggestion of Professor Darwin and Professor Helmert the Malay Peninsula was reconnoitred in 1904 by Mr. H. G. Shaw. It was hoped that a suitable site for a tidal observatory might be discovered on each side of the peninsula. The object of the scheme was to test by means of a line of levels carried across the peninsula from one tidal observatory to the other whether the mean level of the ocean was the same on both sides. Mr. Shaw could however find no suitable place for a tidal station; numerous islands exist which impede the progress of the tidal waves, as they approach the coasts: the foreshores are shelving: between high and low water the sea recedes to a great distance; and the only villages where tidal observers could live are situated on narrow creeks, in which the mean level of the water differs from the mean level of the ocean; the scheme has had consequently to be abandoned.

The observations at Suez and Perim taken between 1897 and 1903 showed that in some ways the tides of the Red Sea were peculiar and abnormal, and Professor Darwin has suggested that an intermediate tidal station at Suakim would be valuable. The present inaccessibility of Suakim renders the erection and annual inspection of a tidal observatory somewhat difficult to arrange for. If Suakim were connected by railway with Cairo the difficulty would disappear, but it is at present doubtful whether the railway that has been projected will not avoid Suakim altogether and join the Red Sea further north. It is therefore not considered advisable to formulate any tidal scheme until the terminus of the railway has been selected.

ON THE GEOGRAPHY OF TIBET.

BY

LIEUT.-COLONEL S. G. BURRARD, R.E., F.R.S.

Within the last few years large areas of the Earth's land-surface have been brought for the first time under survey. During the Somaliland Expedition of 1903 Captain Beazely was able to carry out important surveys. In 1903 and 1904, when the boundary between Aden and Turkish Arabia was being defined by a Commission, Captain M. O'C. Tandy surveyed a portion of South-Western Arabia that had never been previously mapped: and between 1903 and 1905, during the progress of the Seistan Mission, Mr. G. P. Tate made valuable surveys of the inland delta of the Helmand, a little known but very interesting region of Central Asia.

The reports on these surveys in Africa, Arabia and Central Asia have not as yet been published, and it is therefore necessary to postpone till next year any discussion of the geographical results obtained.

In 1904 Major Ryder, D.S.O., and Captain Cowie accompanied the Tibet Mission to Lhasa as survey officers. On the return of the mission to India Major Ryder and Captain Wood carried surveys westward through Tibet along the valley of the Brahmaputra. Major Ryder's maps of Southern Tibet were published in 1905, and form an important contribution to trans-frontier geography.

The existing maps of the Himalayas and Tibet vary from mere compilations of explorers' routes to skilled representations of country. There are fundamental differences between an exploration and a survey: in an exploration there is no basis of triangulation and the narrow route of the explorer is all that is measured; the only heights determined are of places actually visited and inferior methods are used: the map as produced is a skeleton showing the courses of rivers followed, the positions of towns visited and passes crossed.

In a survey the measurements are controlled by a fundamental triangulation; they are extended over a wide area instead of being confined to a line; the heights and positions of all peaks, whether visited

or not, are determined trigonometrically; and the map as produced shows the features, the inequalities and the relief of the surface.

The areas surveyed by Major Ryder and his colleagues had been previously explored by native surveyors, and the sources and courses of the great rivers were known. The Brahmaputra in Tibet was known to be remarkable amongst the rivers of the world for the great elevation of its bed, for the straightness of its course, for the narrowness of its trough, for the paucity of its feeders. *Major Ryder's aim was therefore to survey not to explore.* The exploration of a new country attracts the attention of the public, but the task of the surveyor, who has to observe from the summits of peaks and represent all the details of valleys and ranges on paper, is incomparably harder than that of the explorer, who follows a certain route to discover the source of a certain river. The explorer ascertains a few facts whose novelty renders them interesting, the surveyor contributes a permanent addition to the mapping of the world.

5. So long as Tibet was an unknown country it was advantageous to push explorations, and in the latter half of the last century the native explorers of the Survey of India accumulated valuable information concerning the plateau.

But we have now got out of exploration all that it can give us, and our knowledge of the country will not advance further until we undertake systematic surveys, topographical and geographical, and open regular meteorological observatories. The only region of Tibet in which there is still, perhaps, a use for geographical exploration is the wild country lying towards Burma and China. That the Sangpo river of Tibet falls into the Brahmaputra is a fact conclusively established, but the upper courses of the great rivers of Burma and Siam are still unknown.

Complete ignorance also prevails as to the form of the Karakoram range in its extensions across Central Tibet, and as to how the long parallel folds of the Himalaya Mountains merge eventually into the oblique and diverging chains of Burma and China; but these orographical problems will never be solved by exploration: an explorer can trace a river but not a range.

The central portion of Tibet is composed of a vast number of lakes which have no connection by river with the sea. A survey of these lakes would be valuable, but nothing would be gained by their exploration.

These lakes are supposed by some writers to be drying up, but if that is the case, it is difficult to understand why the process of desiccation should be so prolonged. Though the plateau of Tibet is in its geological youth, it has been in existence for some millions of years, and it is not unreasonable to suppose that the present level of the water in the lakes of Tibet is the final effect of the two opposite processes of evaporation and precipitation after long ages of operation—an effect that will continue so long as the present meteorological conditions remain unchanged. It is useless, however, to speculate on any such question until the fragmentary and casual notes of travellers have been replaced by systematic meteorological observations.

The limits of the catchment basin of the Sutlej.—The twin lakes of Manasarowar and Rakas Tal are the most famous of the lakes of Tibet, and their connection with the drainage of the Sutlej is an interesting hydrographical question. In the mountains surrounding these lakes four great rivers have their rise—the Indus, the Sutlej, the Karnali and the Brahmaputra. There is a stream connecting the two lakes, which Henry Strachey described in 1846 as "100 feet "wide and 3 feet deep, running rapidly from east to west through a well-"defined channel." In December 1904 Major Ryder wrote of this channel as follows:—"No water was flowing at this time of the year, "but the local Tibetans all agreed that for some months in each year "there was a flow during the rainy season and the melting of the snows."

There is also a connecting channel between the westernmost of the two lakes and the main source of the Sutlej: but though there are numerous signs that water has flowed in recent times from the lakes into the Sutlej, yet no known observer has actually witnessed a flow. It may be that the two lakes send off feeders into the Sutlej whenever their water is high, and this was the view taken by Richard Strachey in 1850. Major Ryder writes: "We found an old stream bed issuing "from the Rakas Tal, but every Tibetan we asked told the same story—that no water ever flowed along it now, but that in days gone-by, one

"man saying before the Sikh War, water did flow out of the lake "and down this channel."

It will be an interesting problem to solve whether the Manasarowar and Rakas Tal lakes still continue in seasons of flood to form part of the catchment basin of the Sutlej, or whether they have permanently ceased to do so.

The Tibetan name for Mount Everest —In the course of his work in Tibet Major Ryder endeavoured to ascertain whether the Tibetans had any name for Mount Everest. Mount Everest is situated in Nepal and, as seen from Southern Tibet, is a very prominent peak. When in 1852 it was discovered from the side of India to be the highest mountain in the world, its great elevation was not suspected by the natives of Nepal, and it was not known by a local name. It stands remote from beaten tracks, it is not exposed like Kinchinjunga to the vulgar gaze of man, it marks no goal of pilgrimage like Gangotri or Badrinath.

With the approval of Lord Dalhousie it was given the name of Everest; it was so called after the great mathematician who was the founder of systematic geography in Asia, and who created for the Indian surveys their permanent basis of triangulation.

In 1853 Mr. Hodgson, the Resident in Nepal, raised objections to the name of Everest and maintained that the peak was well-known to the Nepalese under the name of Devadhunga. In 1854 Herman Schlagintweit, a professional geographer, visited Nepal, saw Mr. Hodgson's peak, and discovered that its name was Gaurisankar. These names of Devadhunga and Gaurisankar continued to have advocates for many years, but in 1903 Captain Wood, R.E., made careful observations with a theodolite in Nepal, and found that Hodgson and Schlagintweit had mistaken a nearer peak for Mount Everest.

Of recent years a Tibetan name, Jhomokangar, has been advocated for Mount Everest by Sarat Chandra Das, Mr. Freshfield and others: but the identification rests on no direct evidence. A high peak named Jhomokangar has been mentioned by Tibetans, and from the reports of the latter it has been considered possible that this may be Mount Everest: but no one of the advocates of the new Tibetan name has ever had Mount Everest pointed out to him as Jhomokangar by

Tibetans. When Major Ryder was in Tibet he saw Mount Everest from many points: he subjected his identification of the peak to careful tests with theodolites, and he thus ran no risk of mistaking another peak for it. He was able to point Mount Everest out to Tibetans and ask them the question—"What is your name for that peak?" He found always that they had no name.

In a map published in 1872 to illustrate the explorations of Kishen Singh a mountain was marked Jhomogangar in Tibet, 215 miles north-east of Everest: this name of Jhomogangar has been printed on all subsequent maps of the region. In the account of Kishen Singh's explorations occurs the following passage:—"On January 6th "they reached Dung Chaka 15,700 feet above sea level. About ten miles "to the east there is a lofty snowy peak called Jhomogangar, some- "what of the same shape as the Kailas peak near Manasarowar: it "is a noted object of worship, being considered a female divinity." Kishen Singh was a reliable explorer; his word may be accepted that a sacred mountain exists in Central Tibet that is known by the name of Jhomogangar.

Major Ryder's investigations have finally disposed of the last phase of this question. Neither in Tibet nor in Nepal is Mount Everest known to the inhabitants by any native name.

The highest mountain of Asia.—In 1884 a mountaineer of great enterprise named Graham stated that he had discovered two peaks which he believed to be higher than Mount Everest. He and his companion saw these peaks from a very high point on one of the spurs of Kinchinjunga. Mr. Graham described his supposed discovery as follows:—

> North-west, less than 70 miles, lay Mount Everest, and I pointed it out to Boss, who had never seen it, as the highest mountain in the world. "That it cannot be," he replied: "Those are higher"—pointing to two peaks which towered far above the second and more distant range, and showed over the slope of Everest—at a rough guess some 80 to 100 miles further north. I was astonished, but we were all agreed that in our judgment the unknown peaks, one rock and one snow, were loftier.

Mr. Graham had no instruments with him: he trusted to his eyesight he estimated distances and heights. When we consider the great difficulty of identifying any particular peak amidst the myriads

of its companions without the aid of a theodolite, and when we reflect on the inferiority of the human eye as a range-finder, it becomes a subject for wonder that Mr. Graham's alleged discovery should have been accorded the weight that it has.

The distance of Everest from Kinchinjunga could, of course, be obtained from maps, but to suppose that the human eye unaided is capable of estimating a distance of 170 miles is to go against all experience.

It is more than probable that Mr. Graham failed to identify Mount Everest. Mount Everest does not lie north-west from Kinchinjunga as he thought. It was 77 miles from Mr. Graham's supposed position and not less than 70 as he believed: and if the two higher peaks had been 100 miles *further north*, they would not have appeared over the slope of Everest as he stated, but in a different direction altogether.

Major Ryder's route along the Brahmaputra passed 80 miles north of Mount Everest, and he found no peak approaching Mount Everest in height. The highest peak that he discovered in this part of the country was 8,000 feet lower than Everest.

A traveller who visits Tibet and the Himalayas for the purpose of discovering a mountain higher than Mount Everest has a very poor chance of success. The high peaks of Asia group themselves into two chains, the Himalayan and the Karakoram: and these chains throughout their lengths have been closely scrutinised with theodolites; it is most improbable that the highest mountain of all should have escaped detection.

The whole plateau of Tibet has been intersected by the routes of travellers, and no point on it can now be found that is as much as 80 miles from the track of an explorer. A mountain 30,000 feet in height requires a great elevated base to rest upon; a 30,000 feet peak must be the culminating point of a great range; it must be surrounded by many companion peaks, only less lofty than itself, and it will be visible from a distance of 200 miles. Yet no one of the travellers and explorers who have traversed Tibet has described a mountain mass rivalling Everest or K2.

Nevertheless we cannot state definitely that there is no peak in existence of 30,000 feet. Until Tibet has been systematically surveyed,

we shall have to confine ourselves to the consideration of probabilities; explorers have no means of measuring the heights of inaccessible points, and may be possibly misled in a region of scanty snow-fall by the naked appearance of lofty summits. If however we note the geographical distribution of the great peaks—if we regard the configuration of the Tibet plateau, compressed on the west and widening eastward—and if we consider that the central portion of Tibet is a lake region in which no river has been developed, we are justified in concluding that the existence of a higher mountain than Everest is extremely improbable.

It has been argued that experienced explorers are able to estimate the heights of unknown peaks within a thousand feet. But the mistakes that are constantly being found in the estimated values of heights, when trigonometrical measurements come at last to be taken, show how valueless conjectural geography is.

In his well-known work on Ladak Sir Alexander Cunningham wrote as follows:—"A single peak to the northward of Sassar was estimated "by Dr. Thomson at 24,000 feet. The estimate may be perhaps a little "too high, but I have great confidence in the accuracy with which a "practised eye may measure heights."

Yet Sir Alexander Cunningham himself estimated the height of Nanga Parbat to be 19,000 feet: its correct height is 26,629. In this case the error of conjectural geography was 7,629 feet.

Gerard estimated some of the peaks in Lahoul and Spiti to be 30,000 feet—8,000 feet too great: and many other examples could be quoted to prove that eye observations are worthless.

Summary of Major Ryder's results.—A comparison between Major Ryder's maps and those of the old native explorers has proved the latter to have been accurate and trustworthy observers. They were never able to use instruments openly, and it is wonderful how they measured their routes at all. They were taught to observe for latitude, and their observations were good, but it is doubtful whether they ever knew what a latitude meant. They had no means of checking their longitudes.

Major Ryder found that the towns of Lhasa and Shigatse had been placed on our maps 8 miles too far west: the position of Gartok was however correct to within half a mile. The barometric heights

observed by the explorers were found to be at Lhasa too small by 490 feet, at Shigatse too small by 500 feet, at Gartok too small by 100 feet, at Gyantse by 50 feet, and at the Ma-yum pass by 1,400 feet.

The fundamental difference however between an exploration and a survey is not a question of accuracy; an exploration furnishes a map of a line, a survey furnishes a map of an area. The survey results obtained by Major Ryder may be summarised as follows:— Triangulation was executed connecting Lhasa with India, and fixing all prominent peaks; the country was surveyed on the scale of 4 miles to the inch; on the same scale the whole valley of the Brahmaputra was surveyed from Shigatse to its source; the Manasarowar lake region was surveyed, as also the source of the Gartok branch of the Indus, and the Tibetan course of the Sutlej; the total area surveyed with the plane-table amounted to 60,000 square miles. The survey of the Brahmaputra was carried through with great expedition and in the face of many difficulties: the field work was performed at an average elevation of 16,000 feet and in a climate of Arctic severity.

BOTANICAL SURVEY.

BY

CAPTAIN A. T. GAGE, I.M.S., M.A., B.Sc., M.B., F.L.S.
Acting Director, Botanical Survey of India.

Eastern India.—This, which for Botanical Survey purposes is under the Superintendent of the Royal Botanic Garden, Calcutta, comprises Bengal, the North-Eastern Frontier, Eastern Bengal and Assam, Burma, and the Andaman and Nicobar islands.

In Bengal collections mostly of monocotyledonous plants were made in the Jashpur and Sirguja districts of Chota Nagpur by native collectors working under the kind supervision of the Rev. Father Cardon. Mr. H. H. Haines of the Forest Department contributed to the Calcutta Herbarium a small collection made in the Singbhum district of Chota Nagpur, while the Survey is indebted to Captain C. J. Robertson-Milne, I.M.S., for a representative set of plants from Orissa. The collections made in 1903-04 along the route of the Mission to Tibet, continued

to be supplemented in 1904-05 by additional collections made up to the neighbourhood of Lhasa itself. The Tibetan collections are being elaborated in Europe by Lieutenant-Colonel Prain, I.M.S., but there has not yet been sufficient time to allow of the publication of the results. Advantage was taken of the Road survey operations in connection with the opening up of the Chumbi valley to send up a couple of trained Lepcha collectors, whose work was supervised by Mr. G. L. Searight the officer in charge of the Road Survey. The collections made by the Calcutta Garden collectors in the Chumbi valley were supplemented by collections made by Mr. E. H. C. Walsh, I.C.S. and Mr. J. C. White, C.I.E.

There has not yet been any opportunity of completely working out those collections, but one of the results of the exploration of the Chumbi valley has already proved of considerable interest to botanists and horticulturists alike. This is the re-discovery of the much discussed orchid Cypripedium or—as it is now called—Paphiopedilum Fairieanum, and its re-introduction to cultivation in Europe, to which it had been almost entirely lost for about thirty years. The species was found growing on an exposed situation at an altitude of 3,000—4,000 feet in the valley of the Amu Chhu, or Torsa river. In Sikkim collections were made by Mr. B. B. Osmaston, Deputy Conservator of Forests, while the usual expedition was made by the Curator of the Lloyd Botanic Garden, Darjeeling, to the high levels for seeds of the plants growing at such altitudes for distribution from the Calcutta Botanic Garden to the chief botanical institutions of Europe and America. From British Bhutan collections made by Mr. J. C. White, C.I.E. and Mr. H. H. Haines were presented by them to the Calcutta Herbarium.

In Assam collections were made in the district of Sylhet to link up with those made in the previous year in the adjacent district of Cachar. A collection from Goalpara was also sent by Mr. James Marten, of the Forest Survey. In Burma a collector from the Calcutta Botanic Garden worked over Tenasserim. From the same district the Forest Department sent, as usual, some very interesting collections, which have yielded several new species, and one new genus of a somewhat

aberrant character representing a new tribe of the natural order Sterculiaceae. This latter has been named Mansonia, in honour of Mr. F. B. Manson, lately Conservator of Forests, Tenasserim circle, who has all along given willing help in botanical survey work.

From Lower Burma Mr. J. H. Lace, Conservator of Forest, Pegu circle, sent a collection to the Calcutta Herbarium. From the Shan hills some noteworthy orchids have been sent to the Calcutta Garden, including such species as Cypripedium Charlesworthii and Cypripedium bellatulum.

Mr. I. H. Burkill, Reporter on Economic Products, when in Burma made, with the aid of the Forest Department, important collections of the genus Calamus. He also brought back an interesting collection of fresh water algae which were sent to England to Mr. W. West, the authority on this group, for description and publication.

Mr. Gilbert Rogers, Deputy Conservator of Forests, Andamans, has made collections in the Andaman islands and on Narcondam island, the latter supplementing the collection made on a previous occasion by Lieutenant-Colonel Prain. Mr. Lace has also sent to the Calcutta Botanic Garden a collection from the Andamans. The opportunity afforded by a visit of the Chief Commissioner of the Andamans to the Nicobar Islands was utilised by sending by his kind permission a native collector from the Calcutta Botanic Garden to accompany his party.

Western India.—During the hot weather vacation Mr. Bhide, then in officiating charge of the botanical survey of Western India, completed a collecting tour from Kohalpur to Ratnagiri *viâ* Amba Ghât, returning *viâ* the Phonda Ghât. During the cold weather vacation Mr. G. A. Gammie collected over parts of Guzerat and the Khandesh district. Mr. G. M. Ryan, of the Forest Department, completed his collection of plants of the Thana district preparatory to elaborating them for publication conjointly with Mr. G. A. Gammie.

In Baluchistan excellent collections were made by the Seistan Arbitration Commission under the direction of Colonel the Honourable A. H. McMahon, C.S I.,.C.I.E., who has generously presented them to the Royal Botanic Garden, Calcutta. Mr. R. Hughes-Buller has also made valuable collections in the same province.

Southern India.—From Travancore Mr. T. F. Bourdillon, Conservator of Forests, has contributed a small collection to the Botanical Survey. In the same district a tour was made along the backwaters by one of the assistants of Mr. Barber, Madras Government Botanist, more especially to collect indigenous Indigoferas. Another tour was made along the chief Sandal bearing tracts of Mysore for the formation of a Sandal flora. Mr. Barber himself collected at various places in the Madras Presidency when on tour in connection with his economic work. The flora of Ganjam, including the peculiarly interesting flora of Mahendragiri, a hill which reaches an altitude of nearly 5,000 feet, has been collected and studied by Mr. C. E. C. Fischer of the Forest Department, now in Coimbatore. Collections have also been made in the Godávari district by Mr. G. F. F. Foulkes, the district Forest Officer.

General.—From the foregoing sketch it will be gathered that, except in Upper, North-Western and Central India, a considerable amount of exploration has been done. Most of the collections have gone to the Herbarium of the Calcutta Botanic Garden, where they are being worked up as opportunity permits, although owing to the very inadequate staff progress is necessarily slow. During the year Mr. Duthie, late Director of the Botanical Department of Northern India, sent out another instalment of his Flora of the Upper Gangetic Plain, bringing the work up to the end of Campanulaceae. This, which completes Vol. I of the Flora, was in the Press at the end of the year under review. The Flora of the Presidency of Bombay by Dr. T. Cooke, C.I.E., also advanced a stage during the year, Part I of Vol. II, giving an account of the natural orders from Compositae to Boraginaceae, being published in May 1904. During the year Mr. J. R. Drummond, I.C.S., of the Punjab Commission, since retired, was engaged in the Calcutta Herbarium on the preliminary work in connection with his projected Flora of the Punjab. The elaboration of materials for a Flora of the Malayan Peninsula, based upon the collection belonging to the Calcutta Herbarium, was continued by Sir George King, K.C.I.E., and Mr. J. S. Gamble, C.I.E., and fasciculus No. 15, containing a description of twenty-four genera of the natural order Rubiaceae, was published.

To consider the Botanical Survey from another side, the following natural orders and genera have been studied during the year :—

The Orchidaceae of the North-west Himalaya have been made by Mr. J. F. Duthie the subject of a monograph which is in the Press and will, it is hoped, soon appear as Part II of Vol. IX of the Annals of the Calcutta Botanic Garden.

The Piperaceae of India as represented in the Calcutta Herbarium are under study by M. Casimir de Candolle, the distinguished Botanist of Geneva, to whom also has been sent the Calcutta material of the Meliaceous genus Cedrela. The Calcutta specimens of the natural order Amarantaceae have been under examination by Dr. Hans Zchinz, Director of the Botanical Gardens of Zürich. The Aconites of India have been the subject of special study by Dr. O. Stapf, of the Kew Herbarium, who has written a very valuable monograph on the genus, forming Part II of Volume X of the Annals of the Royal Botanic Garden, Calcutta.

The Indian and Malayan species of the genus Impatiens have been revised and epitomised by Sir Joseph Hooker, G.C.S.I., and the first part of his Epitome has appeared in the Records of the Botanical Survey during the year, while the continuation was in Press at the end of it. The Calcutta material of the genus Nepenthes was sent to the Director of the Royal Botanic Gardens, Kew, to be studied by Mr. Hemsley, F.R.S., the Curator of the Kew Herbarium. Various collections of climbing palms (Calamus) were sent to Signor Odoardo Beccari of Florence, who is the authority for this group of plants. His monograph on the genus which is to form a volume of the Annals of the Royal Botanic Garden, Calcutta, was sent to Press in the course of the year.

To Signor Ugolino Martelli was lent the Pandanus material belonging to the Calcutta Herbarium, to aid him in the preparation of his work on that genus.

Publications.—The official publication of the Botanical Survey of India as a Department is entitled "The Records of the Botanical Survey of India." Although only one of the two officers who constitute the scientific staff of the Calcutta Botanic Garden is an officer of the Botanical Survey, yet the official publication of

the Survey is almost entirely supported by the Calcutta Garden and its correspondents. Of the Records three parts have been published during the year, entitled as follows:—

Vol. III. No. 1. The Vegetation of the district of Minbu, in Upper Burma, by A. T. Gage (pp. 141, with map).

Vol. III. No. 2. The Vegetation of the districts of Hughli-Howrah and the 24-Pergunnahs, by D. Prain (pp. 198, with map)

Vol. IV. No 1. An Epitome of the British Indian species of Impatiens. Part I., by Sir J. D. Hooker, F.R.S.,G.C.S.I.

Papers not published departmentally bearing on the Botany of India comprise the following, of which Part I of Vol. II of the Flora of the Presidency of Bombay, by Dr. T. Cooke; the paper by Sir Joseph Hooker on the species of Impatiens in the Wallichian Herbarium of the Linnean Society: and Sir George King and Mr. Gamble's No. 15 of Materials for a Flora of the Malayan Peninsula are the more important.

A list of papers published during 1904-05 bearing on the Botany of India.

BOURDILLON, T. F. . Eugenia Rama-Varma, a new species. *Indian Forester*, xxx, No. 4, p. 147.

BOURDILLON, T. F. . Eugenia occidentalis, a new species. *Indian Forester*, xxx, No. 5, p. 195.

BOURDILLON, T. F. . Dialium travancorium, a new species. *Indian Forester*, xxx, No. 6, p. 243.

BOURDILLON, T. F. . On two species of black wood found in Southern India. *Indian Forester*, xxxi, No. 3, p. 124.

BRANDIS, SIR D. . . Lindera aromatica. *Hook. Icones Plant.* viii, t. 2784.

BURKILL, I. H. . . See *Prain*.

COOKE, T. . . . Flora of the Presidency of Bombay. Vol. II, Part I. Compositæ—Boraginaceæ.

DRUMMOND, J. R. On a new Scirpus from Baluchistan and certain of its allies. *Journ. As. Soc., Bengal*, lxxiii, pt. ii, 1904, pp. 137—148.

FINET ET GAGNEPAIN . Contributions à la Flore de l'Asie orientale. *Bull. Soc. Bot. de France*, li. pp. 388, 461.

FISCHER, C. E. C. Notes on the Flora of Northern Ganjam. *Journ. Bombay Nat. Hist. Soc.*, xv, No. 4, p. 537.

GAGNEPAIN, F. . . Zingiberacees et Marantacees Nouvelles. *Bull. Soc. Bot. de France*, li. No. 4, p. 164.

GAMBLE, J. S. . . See *King*.

HEMSLEY, W. B. . . Loropetalum chinense. *Bot. Mag.*, 3rd Series, lx, t. 7979.

HEMSLEY, W. B. . . Rosa gigantea. *Bot. Mag.*, 3rd Series, lx, t. 7972.

HEMSLEY, W. B. . . Dendrobium Williamsoni. *Bot. Mag.*, 3rd Series, lx, t. 7947.

HEMSLEY, W. B. . . Vanda pumila. *Bot. Mag.*, 3rd Series, lx, t. 7968.

HEMSLEY, W. B. . . Tupistra Clarkei. *Bot. Mag.*, 3rd Series, lx, t. 7957.

HOLE, R. S. . . A contribution to the Forest Flora of the Jubbulpore Division, C. P. *Ind. Forest.* xxx, pt. 11, p. 499, pt. 12, p. 566.

HOOKER, SIR J. D. . On the species of Impatiens in the Wallichian Herbarium of the Linnean Society. *Journ. Linn. Soc.*, xxxvii, No. 257, p. 22.

KING, SIR G., AND GAMBLE, J. S. Materials for a Flora of the Malayan Peninsula, No. 15, *Journ. Asiat. Soc. Bengal* lxxiii, Part II, No. 3, p. 47.

MAHALUXMIVALA, C. D. Notes on some of the plants introduced into the Victora Gardens, Bombay, during the past eight years. *Journ. Bombay Nat. Hist. Soc.*, xv., No. 4, p. 674.

MARTELLI, U. . . Pandani Asiatici nuovi. *Bull. Soc., Bot. Ital.*, 1904, No. 6, p. 298.

PRAIN, D. . . . An undescribed Indian Musa. *Journ. Asiat. Soc., Bengal*, lxxiii, Part II, No. 1, p. 21. (Noviciæ Indicæ XXI).

PRAIN, D. . . . An undescribed Araliaceous Genus from Upper Burma. *Journ Asiat. Soc., Bengal*, lxxiii, Part II, No. 1, p. 23, with plate. (Noviciæ Indicæ XXII).

PRAIN, D. . . . Four orchids new to the Indian Flora. *Journ. Asiat. Soc., Bengal*, lxxiii, Part II. No. 5, p. 189. (Noviciæ Indicæ XXIII).

PRAIN, D. . . . Some new Indian Plants. *Journ. Asiat. Soc. Bengal*, lxxiii, Part II, No. 5, p. 192, with 2 plates. (Noviciæ Indicæ XXIV).

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STAPF, O. . . . On the fruit of Melocanna bambusoides. *Trans. Linn. Soc.*, 2nd Series, vi, Part 9.

STAPF, O. . . . Arundinaria Falconeri. *Bot. Mag.* 3rd Series. lx, t. 7947.

AGRICULTURAL BOTANY.

BY

E. J. BUTLER, M.B., F.L.S.

Cryptogamic Botanist to the Government of India.

Cereals and food stuffs.—The office of the Reporter on Economic Products has carried nearly to completion the botanical study of the varieties of *juar* (Andropogon Sorghum) grown in India, and the report will soon be ready for the Press. The extent of this inquiry may be grasped from the fact that in Madras alone the Government Botanist has accumulated 680 sheets of specimens, exclusive of sorghum diseases. The investigation of the plants yielding yams, carried on in the same office in collaboration with the Superintendent, Royal Botanic Garden, Calcutta, has also advanced. Similar inquiries on chillies, plantains and Burmese pulses are in progress in the Reporter's office, and the information obtained regarding the latter is almost ready for publication. The Government Botanist, Madras, is engaged on a detailed study of the different varieties of sugarcane at the Samalkota sugar station, which has been enlarged and made permanent during the year. This inquiry includes not only the botanical characters of the varieties but also their agricultural value as regards yield, purity of juice and resistance to red rot. Some Mauritius canes imported into Vizianagram a few years ago were tested both at Samalkota and Pusa, and gave excellent results. Some Barbados seedlings have also been

introduced at Samalkota and their acclimatisation is being attempted. It has been established by Mr. Barber that some of the canes which flowered at Samalkota produced fertile seeds; this opens a way to experiments in the production of seedling canes which have proved so successful in other countries. The Reporter on Economic Products has in hand investigations of the Indian varieties of caraway (Carum), pan (Piper Betel), barley, wheat, Goa bean, and the rice known as Oryza coarctata. Collections of edible mushrooms are being made at the Indian Museum and by the Cryptogamic Botanist working conjointly. A list of famine foods is under preparation in the office of the Reporter. The scientific study of groundnut and black pepper, both of which important crops in South India are falling in cultivation mainly owing to fungus disease, has been provided for by the founding of two experiment stations by the Madras Government. One of these at Palur, in South Arcot, is intended for groundnut and subsidiary crops, and the other at Taliperamba, in Malabar, for pepper. They have been placed under the general control of the Government Botanist, Madras. Professor Wyndham Dunstan, Director of the Imperial Institute, London, has issued a report on the poisonous properties of Lima bean (Phaseolus lunatus), which has been published in the Agricultural Ledger for 1905. His results go to show that while the semi-wild forms grown in Mauritius contain considerable quantities of a glucoside, yielding prussic acid on fermentation, cultivated forms from Burma possess a lesser but variable amount. He recommends the cultivation of the white variety of bean as being the least dangerous in this respect. Major Buchanan's report on the disease known as lathyrism in India, produced by eating Lathyrus sativus, has not yet been published.

Fibres.—The study of cotton, with a view to the extension and improvement of cotton cultivation in India, has attracted a great deal of attention during the year. A detailed account of the work in progress in the several Agricultural departments was published in the Proceedings of the Board of Agriculture in India, in January 1905. The present series of correlated experiments in nearly every Province of India may be considered to have originated in 1902, when the Inspector-General of Agriculture in India collected as complete a set as possible of the existing varieties, submitted them to a preliminary examination and

distributed them to the experiment stations of the principal cotton tracts as a basis for further study. The botanical investigation of Indian cottons was taken up by Professor Gammie; and his second paper, dealing with the species and varieties known in India, their respective areas of distribution, the important question of the degree to which hybridization naturally occurs, the quality of the lint and other similar matters, is now in the press. Mr. Burkill toured in Burma and the Nizam's Dominions for the purpose of studying the cottons of these tracts, and has submitted to Government two notes on the results obtained. In Burma he distinguishes six kinds, and possibly a seventh, two only being of importance, and furnishes notes on their distribution, cultivation, value and the disposal of the produce. The Inspector-General of Agriculture issued a report on the possibilities of extending cotton cultivation in Burma, in which the economic conditions governing the question are dealt with, and proposals are made for testing the behaviour of native and exotic varieties in the different soils of the dry zone, and for improving the local varieties by seed selection and otherwise. He points out, however, that no establishment exists in Burma for carrying on such work. Two notes have been issued on cotton cultivation in Behar by the Inspector-General of Agriculture and by the Entomologist to the Government of India. The former contains proposals for definite experimental work and a preliminary review of the results obtained in the first two years' trials with Indian and exotic varieties. In Mr. Lefroy's note the behaviour of these varieties during 1904-05 is reviewed and the extent to which they were affected by the climate. Acclimatised Americans gave some small promise of ultimate success. The insect pests of cotton in Behar are also briefly described in this note. Mr. Sly, Officiating Inspector-General of Agriculture, inspected the tree cotton experiments of the Indian Long Staple Cotton Growing Syndicate (agents, Messrs. Shaw, Wallace and Co.) and published a note describing them and suggesting improvements. Attention has recently been directed to this class of cottons—perennials—which are usually found in gardens and temple compounds and the lint of which, sometimes fine in quality, is almost exclusively used for weaving the sacred thread of the higher castes. A large number of varieties has been collected from all parts of India, and these are being tested on a considerable

scale by the Indian Long Staple Cotton Growing Syndicate and on a smaller scale elsewhere. Hybridization of cotton is still in progress at the Bombay Farms and elsewhere, and the results are sufficiently advanced in Bombay to hold out considerable hopes of valuable results. It is already fairly clear that no other line of cotton work equals this in its prospects of ultimate success. The trial of long-stapled Egyptian cottons in Sindh by Mr. Fletcher, Deputy Director of Agriculture, Bombay, has given some promising preliminary results. The continuation of these experiments will be watched with the keenest interest. Fifteen-hundred acres have been sown this year to provide a test on a fairly large scale. Extensive arrangements have been made for the selection of the best seed of local varieties in several cotton tracts, with a view to assisting cultivators to improve their crops. The co-operation of ginning factories has been enlisted in some places, as they can materially assist by separating good seed and issuing it, after ginning, to the cultivators. In other places field-to-field selection is being undertaken. This work is independent of the plant-to-plant selection, which is carried out chiefly on the experimental farms.

Jute investigations, taking their origin in complaints of deterioration in the produce made by the trade some years ago, have been continued during the year and the first stage completed by the issue of a report on "Deterioration of Jute in Bengal" by Sub-Committee B of this Board on September the 19th, 1904. As a result of their inquiries the Sub-Committee report that "there is not only no proof that any deterioration in either of the jute plants has occured, but there is a strong evidence that the plants are now precisely as they were a century and more ago. The best kinds, now as then, if cultivated liberally, yield excellent crops, and their fibre, if properly extracted, is also excellent. * * * There is no indication that any radical change has come over the system of steeping and retting, but there appears to be proof that at times fraudulent watering, which induces heating and discolouration, is resorted to with the object of fictitiously increasing the weight of the fibre offered for sale." They, however, express the opinion that "though this is no doubt the explanation of some of the deterioration observed and complained of, it does not explain it all; and in their belief the degeneration is largely due to the fact that whereas formerly only the

best jute, or at all events the jute most suitable for purposes of the Dundee and Calcutta spinner, alone found a sale among jute dealers, now these dealers require so much jute that to fulfil their obligations they must purchase practically whatever jute is offered to them, knowing as they do that what one dealer refuses to buy another will come forward and secure." Experiments are in progress at the Burdwan and Pusa farms, where the most suitable varieties are being tested and the problems connected with jute cultivation studied. Mr. Finlow, special jute expert with the Government of Bengal, has made a preliminary study of the fungus flora of the retting waters, assisted by the Cryptogamic Botanist, and has also commenced an investigation of the bacteria concerned in the process of retting.

Agave fibres still attract much attention. The Botanical inquiry into the identity and distribution of the various agaves and Furcræas by Lt.-Col. Prain and Mr. Drummond was recently finished and is now in the Press. A valuable bulletin on Sisal Hemp Culture in the Indian tea districts by Dr. Mann and Mr. Hunter was issued by the Indian Tea Association. The Aramina fibre of Brazil, which has attracted some notice, has been grown in the Calcutta Botanic Gardens and identified as Triumfetta rhomboidea, a common tropical plant of no special value as a commercial fibre producer. At the same institution the inquiry into the sources of Indian or Sunn hemp, Crotalaria juncea, was continued, the fibre of plants grown from various parts of the country having been sent to England for valuation. The investigations of the fibres of Calotropis and plantain have been continued in the office of the Reporter on Economic Products.

Dyes and tans.—Three papers dealing with Indigo were published by Mr. Leake. He has investigated the localization of the indigo producing substance in the plant by improved methods, and finds that the results of earlier workers cannot be considered proved. The variations induced in Indigofera sumatrana by climatic conditions are considered in a second paper and elucidated by maps. Both the lines of equal rainfall and equal temperature enclose areas agreeing with the areas in which the various types are found. This throws some light on the question of the choice of the locality for seed areas. In a third paper the occurrence of hard seed in Indigofera arrecta, "Natal" Indigo, is

noted and suggestions for treating the seed-coat are made. This indigo, which is now so highly thought of in Behar, germinates with such difficulty that seed treatment is likely to become habitual. Some simple machines for the purpose have already been devised. The Government Botanist, Madras, has collected some South Indian varieties of Indigofera, particularly the rare I. longeracemosa and I. Anil, for trial at the Palur farm.

Mycology and plant Pathology.—A bulletin by Messrs. Mann and Hutchinson on "red rust" Cephaleuros virescens of tea was issued by the Indian Tea Association. It contains the results of careful observations and experiments carried on over several years. The life history of the parasite and relations between it and the host plant are described and recommendations for treatment given. The general conclusion of the authors is that it is a disease primarily induced by weakness of the tea bush due to unsuitable soil, want of drainage and bad cultivation. Vigorous, well cultivated gardens are rarely damaged. The same Alga was found by the Cryptogamic Botanist to produce a serious disease of mango trees at Malda, possibly the most important mango growing district of India. Grafts chiefly are affected, the parasite attacking the young twigs and producing their death eventually by destruction of the bark. The analogies with the attacks on tea were very evident. A second mango disease, due to Gloeosporium Mangiferæ, is destructive to the young flushes in Dehra Dun.

In the Cryptogamic Botanist's office the wilt disease of arhar, Cajanus indicus, has been further studied and the pepper disease of the Malabar district was found associated with the same fungus, a species of Nectria. A note on the latter was published in the Proceedings of the Wynaad Planters' Association in October 1904, and a detailed account of the two diseases has been recently submitted for publication. A second pepper disease occurs in Mysore, due to one of the root rotting fungi, Rosellinia bunodes, and instructions for its treatment have been issued to those concerned. Groundnut *tikka* disease (Septogloeum Arachidis) is still under study; a second disease of this crop, less destructive than the other, has been noted this year at Dehra Dun. Rice smut and *chhatra* disease of paddy are under study. The latter was found in some cases associated with the fungus Sphaerella Malinverniana

to which has been ascribed similar diseases in Italy and Japan, but it was not always discovered on diseased plants. Several new coffee diseases have been investigated, one of which, examined locally in the Nilgiris, appears to be very serious. It is apparently caused by a species of Gloeosporium which attacks the twigs. Experiments in its treatment are in progress. In Sylhet several of the coffee diseases prevalent in South India were found established in an estate visited. The Areca palm plague in the same district was investigated and determined to be due to a fungus attacking the base of the palm, the exact nature of which is not yet known. A report was submitted to the Assam Department of Agriculture from which a vernacular leaflet, giving some suggestions for dealing with it, is in preparation. A serious outbreak of disease in Palmyra, cocoa and areca palms in the Godávari Delta was also investigated, the cause here being a species of Pythium which attacks the leaf stalks and terminal bud, thus killing the tree. The inquiry is still proceeding. The disease of sisal hemp due to Çolletotrichum Agaves has been reported from several districts and was studied in Sylhet. Suggestions for treatment have been given. Two rubber diseases have been examined, the canker of Hevea from Burma and a Botryodiplodia disease of Castilloa elastica from the Anamalis, and treatment recommended. The rust of *juar* (Andropogon Sorghum) and *bajra* (Pennisetum typhoideum) have been identified and have proved to be distinct species, contrary to the opinion of the late Dr. Barclay. "Green ear" disease of the latter cereal was found to be induced by the attacks of a new species of Sclerospora on the leaves. It is still under study. Amongst the most serious diseases reported during the year is the cotton wilt of the Punjab, which appears to be the same as that which has been one of the worst enemies of the cotton cultivation in the United States. The area affected is probably small and efforts will be made to stamp it out, but it must remain for some time a cause of much anxiety. A somewhat similar disease has been found on jute. The mildews which affect a number of Indian crops are being studied by Mr. E. Salmon at Kew, to whom collections have been sent. Tobacco, mulberry, orange, several pulses, castor oil, wheat, coriander and Trigonella are amongst the plants attacked.

The poisonous properties of the cereal *kodra* (Paspalum scrobicu-

latum) are under study in the Cryptogamic Botanist's office, as there is some reason to believe that they result from a fungus often found in the grain.

The work on wheat rusts carried out in conjunction by the Cryptogamic Botanist and the Deputy Director of Agriculture, United Provinces, was continued. A paper was completed by them in 1904 but has been delayed in publication. This gives details of the chief rusts, considers their mode of transmission from year to year, their specialisation on different host plants and the influence of meteorological conditions on the disease. Mr. Moreland has contributed a note on the latter point based on observations in selected districts of the United Provinces during a number of years. A short note by the Cryptogamic Botanist on the degree to which the liability of wheat to rust depends on secondary infection by Uredospores rather than on the severity of the first outbreak of the disease is in the Press.

The paper on sugarcane diseases in Bengal submitted by the Cryptogamic Botanist in the first half of 1904 has not yet appeared owing to delay in publication. The Government Botanist, Madras, is endeavouring to raise canes resistant to red rot at the Samalkota farm and is continuing his study of the behaviour of different varieties of cane to it.

Mr. A. Nechitsch, of Geneva, has investigated the fungi producing the fermentation of alcoholic beverages prepared from rice in Sikkim and the Khasia hills. The chief fungi concerned are named Mucor Prainii and Dematium Chodati. Their fermentative activity under different conditions is described.

The preparation of a text book on plant diseases in India has been commenced by the Cryptogamic Botanist.

Miscellaneous.—A large number of references to the economic and agricultural uses of certain plants in Burma and Bengal occur in Vol. 3 No. 1, No. 2 of the records of Botanical Survey of India by Captain Gage and Lt.-Col Prain, respectively.

The use of copper sulphate in purifying tank and well waters by killing algæ and bacteria without injuring the higher forms of life, as described by Dr. Moore of the United States Department of Agriculture, has been extensively tested in India during the year. Dr. Cook, Health Officer, Calcutta, Dr. Turner, Health Officer, Bombay,

Lt. Christophers, Superintendent, King Institute, Madras, and others have issued reports on the results of their trials. Dr. Cook states that he is reluctantly forced to the conclusion that copper sulphate in the quantities prescribed by Drs. Moore and Kellarman is of little practical use for the purification of the filthy tanks that abound in Calcutta. The other workers generally arrive at the same conclusion. Interesting notes are supplied in Dr. Cook's report on the algal vegetation of Calcutta tanks.

The following papers dealing with Agricultural and Economic botany appeared during the year.

1. Proceedings of the Board of Agriculture in India, 1905.

2. Agricultural Ledger No. 2 of 1905, Phaseolus lunatus (Lima or Duffin Bean).

3. Note on Cotton Experiments in Behar by J. Mollison.

4. Notes on Cotton in Behar by H. Maxwell-Lefroy.

5. Report on Cotton in Burma by I. H. Burkill.

6. Notes on Cotton made at Bhainsi, Nizam's Dominions, by I. H. Burkill.

7. The cotton experiments of Messrs. Shaw, Wallace & Co. by F. G. Sly.

8. Selected papers on inquiry into deterioration of jute, Government of Bengal.

9. The localization of the Indigo-producing substance in Indigo-yielding plants, by H. M. Leake: Annals of Botany, XIX.

10. The occurrence of "hard seed" in Indigofera arrecta *Hochst*, by H. M. Leake: Journal, Royal Horticultural Society, Vol. XXIX, pts. 1 & 2.

11. Variation in Indigofera Sumatrana Gaertn. as induced by climatic conditions, by H. M. Leake: Journal Royal Horticultural Society, Vol. XXIX, pts. 1 & 2.

12. Sisal hemp culture in the Indian Tea Districts, by H. H. Mann and James Hunter. Indian Tea Association, No. 3 of 1904.

13. Progress report on the work of the Samalkota Experimental Sugar Farm during 1903-04, by C. A. Barber.

14. Red Rust: a serious blight of the Tea plant, by H. H. Mann and C. Hutchinson, Indian Tea Association No. 4 of 1904.

15. Sur les ferments de deux levains de l'Inde, le Mucor Praini et le Dematium Chodati, by A. Nechitsch, Institut de Botanique, Université de Genève, 6e. ser., Ve. Fasc. 1904.

16. Pilzkrankheiten in Indien im Jahre 1903, by E. J. Butler, Zeitschrift fur Pflanzenkrankheiten, Bd. XV, Heft 1.

17. Pepper vine disease, by E. J. Butler, Proceedings Wynaad Planters' Association, October 1904.

18. The uses of Copper as an Algicide and Germicide by Dr. J. Nield Cook, Calcutta, July 1905.

FOREST BOTANY.

BY

H. H. HAINES, F.L.S., F.C.H.

Deputy Director, Imperial Forest School.

The subject matter of this part of the report has been roughly divided into two sections according as the work recorded has been carried out by members (active or retired) of the Forest Department, or by investigators outside the department. This division cannot be absolute, as much work in Forest Botany is done conjointly.

Section I. By far the most important work under preparation during the year has been that by Sir D. Brandis entitled "Indian Trees," of which Part I has already been some time in print and the greater part of Part II is now in the Press. A considerable number of specimens have again been forwarded to Sir D. Brandis from various officers during the year, many of which however have arrived too late to be made use of.

Of new species actually published there have been but few. Lindera aromatica *Brandis* appeared in Hooker's Icones[1] and Mr. Bourdillon has published in the Indian Forester[2] plates as well as descriptions of the following trees:—Dialium travancoricum *Bourd.* a magnificent evergreen tree from South Travancore. This tree was provisionally referred to D. coromandelianum *Houtt.* in Gamble's Manual. Eugenia Rama-Varma *Bourd.* from the evergreen forests of Travancore and Tinnevelly, and E. occidentalis *Bourd.* a small tree from the same parts.

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[1] Hook Icones Plant T. 2784. [2] Indian Forester, Vol. xxx. Nos. 4, 5, 6, 8.

Colonel Beddome in writing his Flora Sylvatica some 30 years ago alluded to Dalbergia sissoides, Grah. as possibly distinct from D. latifolia with which he united it. Colonel Prain[1] united D. sissoides with D. emarginata, Roxb., a tree of the Andamans but Sir D. Brandis dissents from this view. Mr. Bourdillon[2] has now given good reasons for maintaining D. sissoides Grah. as a distinct species, and has suggested the English name "Malabar black wood" for it.

A note on the Flora of the Jubbulpore Division, Central Provinces, and a list of the trees, shrubs and climbers has been drawn up by Mr. R. S. Hole[3] which though admittedly incomplete is of considerable value. Jubbulpore is interesting as being in the area where the Teak and Sal meet. As usual the Director and Curator of the Herbarium, Calcutta Botanic Gardens, have given much assistance in naming doubtful specimens. Mr. Hole has given vernacular names, but unfortunately he does not specify the particular races who use these names. Dates of flowering and fruiting are given where known, as also in a few cases sylvicultural and other useful notes.

Notes on the flora of Northern Ganjam have been compiled by Mr. C. E. C. Fischer[4]. This district is practically the southern limit of Sal, a few only occurring in the Vizagapatam district. Mr. Fischer's notes are not confined only to forest botany however, but include flowering plants generally.

A preliminary list of the plants of the Chittagong Hill Tracts and Collectorate has been prepared by Mr. Heinig,[5] who is now engaged on its further elaboration.

An incomplete list of the trees and shrubs of the Sub-Himalayan tract of the Champaran district was drawn up by Mr. Haines and printed as an appendix to a report on the Bettiah Raj forests[6], and a commencement was made in the writing of a Forest Flora of Chota Nagpur.

In September 1904 Mr. Ryan read a paper before the Bombay Nat. Hist. Society[7] on the water-yielding plants of the Thana forests but this chiefly deals with Calycopteris floribunda.

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[1] Jour. Asiatic. Soc., lxxx, No. 1, p. 41. [2] Indian Forester Vol, xxxi, No. 3. [3] Indian Forester Vol. xxx, Nos. 11, 12. [4] Journ. Bombay Nat. Hist. Soc., Vol. xv, No. 4. [5] Not yet published. [6] Official paper only. [7] Journ. Bombay Nat. Hist. Soc., Vol. xvi, No. 1, p. 65.

It is impossible to enumerate here all the hitherto undescribed species of which specimens have been communicated by Forest Officers to various herbaria. Perhaps the most interesting of these were contained in collections sent by Mr. Manson from Tenasserim, one of the trees called kalamet with fragrant wood, which Mr. J. R. Drummond, I.C.S., retired, late of the Punjab Commission, has proposed to name Mansonia Gagei. Mr. Osmaston also made considerable additions to the Sikkim Flora. A forest flora of the Sikkim and British Bhotan Hills is very badly required. Such a work had actually been commenced during the year but was put a sudden end to by the transfer of both the officers engaged on it.

Turning to another line of enquiry, the question of root suckers has been engaging considerable attention.[1] Some of the writers contend that the members from which suckers arise are morphologically underground branches, but there is no doubt whatever that most suckers in the case of trees spring from adventitious buds formed in true roots. The main object of the discussion however has been to show the very large number of trees which tend to form suckers, especially under the influence of some stimulus such as the felling of the principal stem or the uncovering or the wounding of superficial roots. Altogether some 94 species of Indian trees distributed among 28 orders are now known to produce suckers. Of these the Leguminosæ furnish 28 species.

Mr. Rama Rao, who has before furnished most valuable notes on the root parasitism of the Sandal, again followed up the subject during the year,[2] and has discovered evidence of the parasitism on upwards of 70 species of plants. In 1884 Hutchins had noticed that Sandal did not succeed in pure woods, and other Forest Officers (notably Messrs. McCarthy and Lushington) have from time to time given evidence of parasitism, but a scale of species arranged to show the best hosts for the Sandal is still a sylvicultural desideratum. Mr. Rama Rao has indicated the Mimoseae as good nurses, but some of his observations in this direction (*e.g.*, in the case of the Anonaceae) do not quite tally with Mr. Barber's investigations.

[1] *Vide* letters by Messrs. Lushinghton, Ryan, Hobart Hampden, Stevensand Gleadow in Indian For., Vol. xxx, Nos. 4, 7, 10. Vol. xxxi, No. 3. [2] Indian Forester, Vol. xxx, Nos. 6, 8, 9.

Section 2. Forest Botany outside the department.

The hemi-parasitism of Santalum has long been suspected. Scott discovered the haustoria as long ago as 1871, Warming and Strasburger have described the whole of the Santalaceae as root parasites, and Schimper refers to Santalum as hemi-parasite. Doubts have however sometimes been raised on the point and several systematic works make no reference to its parasitic nature. Mr. Barber has not only finally established the hemi-parasitism, but has fully described and illustrated the anatomy of the haustoria and their connections with the roots of other plants.[1] He also shows that the Sandal exhibits a marked preference for certain hosts, but it does not appear to be nearly so particular in its selection as many other parasites, and the haustoria have been found to attach themselves to the most various objects. Mr. Barber is engaged on the study of the whole family morphologically and oecologically, as well as of other Phanerogamic parasites.

In the June number of the Transactions of the Linnean Society[2] appeared Dr. Stapf's valuable contribution to the natural history of the bamboos. This deals with the remarkable "berry-bearing" genera Melocanna, Melocalamus and Ochlandra. Melocanna has been fully described. The whole structure and development of the ovules and fruit is most unlike that of other Gramineae. The ovules are naked, so that the seeds have no testa, while the endosperm is reduced to a mere film ("diaphragm" of Stapf), the scutellum is enormously developed and the embryo is sharply curved. The large fleshy pericarp becomes filled with starch which, as the embryo and young plant develop, is absorbed by the scutellum. The genus is viviparous.

Contributions to Forest Systematic Botany by botanists outside the department are usually included in works covering a wider field. The Monograph of the genus Diospyros in Ceylon by Mr. Herbert Wright is however essentially of forest interest.

In the series of papers entitled Noviciæ Indicæ, by Colonel Prain, while new localities are given for a large number of Forest species, one new genus "Woodburnia" (Araliaceæ) [3] is described and descriptions given of the following trees and shrubs, [4] *viz.*, Sterculia

[1] Indian Forester, Vol. xxx, No. 12. Vol. xxxi, No. 4. [2] Trans. Linn. Soc. Vol. vi, Bot. Part 9, p. 401. [3] Journ. Asiat. Soc. Beng. lxxiii, Part II, No. 1. [4] Id. No. 5

Kingii *Prain*, of which complete specimens were sent by Mr. Osmaston, is a not uncommon small tree in Sikkim; Euonymus macrocarpus, *Gamble;* E. kachinensis, *Prain;* E. subsulcatus, *Prain;* E. Wrayi *King;* E. viburnoides, *Prain;* E. Lawsoni, *Clarke;* Gymnosporia sikkimensis, *Prain;* G. Curtisii, *King;* Crudia Mansoni, *Prain;* Humboldtia Bourdilloni, *Prain;* Rosa gigantea, *Collett;* R. Collettii, *Crepin;* Pyrus Kurzii, *Watt;* Terminalia burmanica, *King;* Woodburnia penduliflora, *Prain;* Musa Nagensium, *Prain.* Colonel Prain has also revised the species of Celastrus as diagnosed in the Flora of British India, and in doing so described three new species.[1] He also continued his descriptions of the Asiatic species of Ormosia.[2] The family of Dioscoreaceæ are important in forest botany from their being so often used as food by jungle tribes, while some are extensive climbers. Hitherto published accounts of the species have been inadequate for their determination. They have recently been very thoroughly studied both wild and in cultivation by Prain and Burkill, and in addition to several new species from China and Japan, three new species have been recorded from Burma and one from Sikkim [3], De Candolle argued a recent cultivation of the yams in India, but D. alata is now cultivated all over India, Ceylon and Burma as well as China, and according to De Candolle, also the Pacific Islands: but, he added, "no one pretends to have found this species in a wild state." It is a most interesting discovery of Mr. Burkill's, therefore, that this species is wild all over the Northern Shan States, and he has probably discovered the original home of this important plant.

During little less than a month's tour in the Minbu district of Upper Burma Captain Gage has added a new locality to between 40 and 50 woody plants, and has described new species of the following genera:—Boscia (Capparideæ) Bombax (probably new, though previously included in B. insignis by Kurz), Vitis, Indigofera, Derris, Argyreia, and Lettsomia, (the last two scandent and scarcely woody). A list of the plants is accompanied by a general description of the topography and vegetation with a discussion of its affinities and distribution.

Uniform with Colonel Prain's eminently useful and interesting Flora of the Sunderbans, we now have a Flora of the districts of

[1] Journ. Asiat. Soc. Beng. lxxiii, Part II, No. 5. [2] Id. No. 2. [3] Id. No. 4.

Hughli-Howrah and the 24-Pergunnahs. Important as this is botanically, "as there is not a forest, and scarcely perhaps an indigenous forest tree" in the whole area, excepting that portion forming part of the western Sunderbans and, as this is necessarily included in the author's previous work, the book is of only indirect interest from the standpoint of Forest Botany.

The "Botanical Regions" of South India have been fully described by Mr. Barber in an article on Botany to the Imperial Gazetteer, while notes on the Flora of South Arcot and Godaveri have been contributed to the District Manuals. Other Forest districts have also been under special study with the assistance of the Forest Department, the results of which are not yet published.

In the province of cryptogamic botany Mr. Butler has investigated several diseases of trees during the year. Among these a disease of Pinus excelsa has been found to be due to the well known European fungus parasite Trametes Pini, which attacks Pines, Firs, Spruce and Larch. In one forest in the Simla division half the trees are reported to be attacked and the timber rendered useless from the "spongy red-rot of the heart wood" which results. The treatment must lie in "preventing the hacking of branches and the removal of infected trees."

The "Witch's Broom" of the deodar, common in Jaunsar, is found to be due to Peridermium Cedri, a fungus, so far as is known, peculiar to the Himalaya. The Casuarina root disease which is prevalent in some plantations on the East Coast is produced by a fungus of the genus Trichosporium, which invades the roots and collars of the trees and kills them off in centrifugally expanding patches. An account of the disease by Mr. Butler will shortly appear in the "Indian Forester." Root-rot of a number of trees, including Schleichera, Holigarna longifolia, Grevillea, species of Litsea, &c., in the Mysore Ghât tracts has been ascertained to be the result of Rosellinia bunodes, a fungus probably arising, like other destructive Rosellinieæ, in decaying wood.

Attempts to produce the "spike" disease of Sandal by artificial inoculation have failed, and no further light has been obtained regarding its cause. An interesting photograph of the effects of this disease on the Sandal was communicated by Mr. Lushington to the "Indian Forester" in the January 1905 number.

FOREST PRODUCTS.

BY

M. HILL, F.L.S.
Assistant Inspector-General of Forests to the Government of India.

In collaboration with the Reporter on Economic Products to the Government of India, a large amount of work was done during the year in connection with the collection, investigation and analysis of Forest products, including gums, resins, rubber, oils, dyes, tans, fibres, timbers, &c.

Gums.—Gums of numerous species of forest trees and climbers were collected with the object of determining the properties of Indian gums and ascertaining which are suitable for export.

The gum obtained from the Dhaura tree (Anogeissus latifolia) yielded a colourless solution, highly visoid and adhesive. It is considered very suitable for export.

The gum obtained from Pithecolobium lobatum, a tree growing in Hanthawaddy, Burma, formed a dark coloured solution with water which readily fermented. It was therefore of little value.

Resins.—Resins of several species, including Dipterocarpus tuberculatus, Pentace burmanica, Hopea odorata, Mesua ferrea, &c., were obtained from Burma and Assam. The resin of Hopea odorata has formed the subject of report by Professor Dunstan (Commercial circular No. 1 of 1904) and that of Altingia excelsa has been described in Agricultural Ledger No. 9 of 1904.

Oils.—The enquiry into Indian oils inaugurated by Sir Frederick Abel is making fair progress. During the year oils of Amoora Rohituka and Calophyllum tomentosum were collected and sent to the Reporter on Economic Products, who forwarded them to the Imperial Institute. Seeds of Croton oblongifolius were collected in Bengal for analysis.

A report on the seeds of Schleichera trijuga as a source of Macassar oil was issued in Agricultural Ledger No. 1 of 1905.

Tannins.—Pods of Caesalpinia digyna from Burma were distributed to various tanneries for experiment and report. The roots of Rumex

hastatus and Polygonum nepalense were analysed to determine their strength in tannic acid: the former yielded from the dried roots the following amounts of extractive matter and tannin:—Aqueous extract 18·2, tannin 11·6, and the latter 29·9 aqueous extract and 15·9 tannin.

Preliminary investigations into the possibility of utilizing the barks of Shorea robusta and Terminalia tomentosa as tanning materials were made by the Director, Imperial Institute, London, and the results obtained so far tend to show that it is likely that the extracts obtained from these species will, when employed as tanning materials, furnish leathers of good texture and colour. Arrangements have been made for the preparation of extracts from these barks at the Government tannin extract factory, Rangoon. The extracts will be forwarded to the Imperial Institute for chemical examination and commercial valuation.

The bark of Artocarpus Lakoocha, which is frequently used for tanning in Assam, was examined and found to contain 8·5 per cent. of tannic acid.

Turpentine oil and resin from the United Provinces have been sent to the Imperial Institute for chemical and commercial valuation.

Considerable quantities of turpentine and colophony are now manufactured in the United Provinces. During the year 62,000 pine trees were tapped, yielding an average of 2·7 seers of crude resin a tree. Each maund of crude resin yielded 1·4 gallons of turpentine and 25·6 seers of colophony.

Rubber.—A large number of samples of crude rubber of various species were collected from different provinces, and analysed by the agricultural chemist to the Government of India.

Samples of rubber from Assam and Burma were sent to the Imperial Institute, London. A report was made on the yield of rubber from the dried bark and leaves of Ficus elastica, from which it appears that it is very doubtful whether the yield and quality of the rubber even from fresh bark or leaves would be sufficient to justify attempts to extract it upon a commercial scale.

Samples of crude rubber obtained from the following species yielded upwards of 50% of caoutchouc:—

Rhynchodia Wallichii 86·5 %—This specimen was obtained from Tennasserim, Lower Burma, and examined at the Imperial Institute, London. The physical properties of the rubber were found to be very satisfactory: it was valued at 3*s*. 6*d*. a lb, the rate for Para rubber at the same time being 4*s*. 8*d*. a lb.

Ecdysanthera micrantha 84 %—This plant, known in Burma as "Nwede," is a climber and has only been definitely recognized as a source of rubber during the last two or three years. It is stated to occur in Assam, Burma, Siam, Southern China and French Indo-China, and in the last named country it is exploited by the natives for its rubber.

The rubber was reported by Professor Wyndham R. Dunstan to be of good quality though the percentage of resin (11·5) found was higher than desirable.

Two samples of crude rubber obtained from a climber (Anodendron sp. ?) in the Kengtung forests, Southern Shan States, yielded 94·6 per cent. caoutchouc. The rubber was most favourably reported on and valued at about 4*s*. a lb.

A sample of crude rubber of Ficus elastica from Upper Burma yielded 82·6 per cent. caoutchouc. And crude rubber of Cryptostegia grandiflora from Bombay yielded 83·4 per cent., while a variety of other samples, principally Ficus sp. yielded from 3·9 per cent. to 50 per cent. caoutchouc. The majority of the analyses were made by Dr. Leather, Agricultural Chemist to the Government of India.

Yams.—A number of yams—Dioscorea sp.—were collected from different provinces and will form the subject of an important enquiry jointly undertaken by Mr. Burkill and Colonel Prain.

Canes.—A number of canes from Burma, Madras, etc., were collected. Some of these are of great botanic interest, a specimen from South Coimbatore having proved to be Calamus Rheedei, a species hitherto only known from Rheede's figure. At the suggestion of Sir Dietrich Brandis, duplicates of the botanical specimens are being submitted to Dr. Beccari, of Florence, for his opinion.

Fibres.—A variety of plantain fibres was collected from different provinces, and these will be described in connection with the botanical

origin of the plants, and their comparative breaking weights will be recorded.

The fruits, roots, leaves, etc., of poisonous Daturas were collected in connection with the investigation to determine the amount and nature of the alkaloid present in these plants. The chemical constituents of the seeds of Gynocardia odorata, Taraktogenos Kurzii and Hydnocarpus Wightiana collected in Assam, Madras, etc., were reported on by Dr. F. B. Power.

Timbers.—A very large number of timbers of various species were collected from different provinces and supplied to the Reporter on Economic Products, the Director, Botanical Survey of India, the Principal, Civil Engineering College, Sibpur, and Museums and Institutions in India and America.

Wood pulp.—As a result of enquiries regarding the feasibility of utilizing in the form of wood and bamboo pulp, the large quantities of inferior species of trees and of bamboos contained in the forests of India, which at present possess little or no commerical value, the services of a competent expert has been arranged for, with the object of thoroughly investigating on the spot the conditions on which it would be possible to start the industry.

Botanical Specimens.—Numerous botanical specimens were collected in most provinces and sent to the Royal Botanic Gardens, Calcutta and Kew, and to the Reporter on Economic Products, India, and to the latter were also sent, from the Bombay Presidency, a collection of fruits, roots and seeds likely to be suitable as famine foods.

Seeds.— A quantity of seeds of the more important Indian species, including Cedrus Deodara, Pinus longifolia, Cupressus torulosa, Dalbergia Sissoo, Shorea robusta, Tectona grandis, etc., etc., and a variety of bamboos were collected and despatched to British Colonies and Foreign Governments and Institutions.

General.—286 Samples of various products were tested and examined in the laboratory of the Industrial Section, Indian Museum, under the superintendence of Mr. D. Hooper, F.L.S. Among the food stuffs examined, the following three are of interest. Fruits of Cactus (Opuntia Dillenii from Nellore), roots of Aponogeton monostachyun

from North Salem. The Dodder plant (Cuscuta reflexa) :—

	Opuntia.	Aponogeton.	Cuscuta.
Water	5·67	7·50	6·75
Fat	3·63	·76	1·90
Albuminoids	6·25	9·18	9·62
Carbohydrates	41·89	71·00	65·68
Fibre	32·00	3·50	10·10
Ash	10·56	8·06	5·95
	100·00	100·00	100·00

Some seeds of Pithecolobium lobatum were sent from Tennasserim for a report on their value as a food-stuff. On analysis they were found to contain some 69 per cent. of carbohydrates and 17 per cent. of Albuminoids, with small quantities of fat, fibre and water.

Pine needles of the chil pine (Pinus longifolia) were examined to ascertain their value in oil or other commercial product contained in them, with the result that it was found that neither essential oil, resin nor tannin was in sufficient large proportion to pay for its extraction. Among other products, not already referred to, which formed the subject of investigation may be mentioned "Pwenyet," the product of the Melipona laeviceps or Dammar Bee of Burma ; a whitish resin from the Hollong tree (Dipterocarpus pilosus) ; a green resin of Calophyllum inophyllum, characterised by its solubility in alcohol, its high acid value and its coumarin-like aroma. A number of samples of Cutch were tested to ascertain the amount of tannin, soluble non-tannins, insoluble matter and ash. The percentage of tannin in good samples varied from 40 to 70. The Burmese Cutch was found to be uniformly good. Specimens of adulterated Cutch were rare.

Burmese Storax, oil-seed of Dichopsis ovata, fruits of Olea cuspidata (the Indian olive), fibres of Sabai grass from Nepal Terai, of the climber Bauhinia Vahlii, of wild cardamom of Assam (Alpinia Allughas) and of sunflower (Helianthus annuus) and various medicinal products also formed the subject of study and investigation during the year.

List of books and papers bearing on Forestry, Forest products, etc., in India received or issued during 1904-05.

1. Flora of the Upper Gangetic Plain and of the Adjacent Siwalik and Sub-Himalayan Tracts, Vol. I, Part II . . . . by J. F. Duthie, B.A., F.L.S.
2. Schlich's Manual of Forestry, Vol. III, Forest Management, 3rd Edition . . . by W. Schlich, P.L.D., C.I.E., F.R.S., F.L.S.
3. Note upon the "Bee-hole" Borer of Teak in Burma. . . . . by E. P. Stebbing, F.L.S., F.Z.S., F.E.S.
4. Note on the Quetta borer . . . by E. P. Stebbing, F.L.S., F.Z.S., F.E.S.
5. Note on the Chilgoza bark boring insects of Zhob and Baluchistan . . . . by E. P. Stebbing, F.L.S., F.Z.S., F.E.S.
6. The Cultivation and preparation of Para Rubber . . . . . by W. H. Johnson.
7. Firminger's Manual of Gardening . . by J. Cameron, F.L.S.
8. Review of Forest Administration in British India for the year 1902-03 . . . by S. Eardley-Wilmot, Inspector-General of Forests, Govt. of India.
9. A paper on the gums of various species of Acacia. (Indian Forester, September 1904) by D. Hooper, F.C.S., F.L.S.
10. Altingia excelsa (Burmese Storax) Agricultural Ledger No. 9 of 1904 . . . by D. Hooper, F.C.S., F.L.S.

THE PROGRESS OF ZOOLOGY IN INDIA DURING THE YEAR 1905.

BY

LIEUT.-COL. A. W. ALCOCK, I.M.S., C.I.E., M.B., C.M.Z.S., F.R.S.
Superintendent of the Indian Museum.

This is a brief review of the principal work in Indian zoology published between the 1st December 1904 and the 30th September 1905. It deals with zoology in the ordinary, restricted, sense of the term: it does not include certain memoirs that have appeared in the Royal Society's *Proceedings* and *Transactions*, and in the "Scientific Memoirs," on the physiological properties of snake-venom; or the papers, of purely pathological interest, that have been published in the "Scientific Memoirs" and in the Quarterly Journal of Microscopical Science, on certain Protozoan blood-parasites of man: nor does it embrace the subject of Economic Entomology, which is dealt with by a separate agency.

In the period under report I have found 80 series of papers (not separating the multifarious Notes and Queries contributed by sportsmen and enthusiastic members of the Bombay Natural History Society to the "Miscellaneous" Appendices of their *Journal*) dealing either exclusively or in major part with the Indian fauna: of these no less than 55 are the work of zoologists living in Europe, and only 25 have been contributed by India. This is a strange record for a country where Universities and their affiliated colleges are now quite numerous and the choicest material for zoological research is to be found almost at the door of every student; and it shows that in India, far more even than in other parts of the British Empire, the value of the study of zoology—even in its practical applications to human safety and comfort, and to some of the most important, if simplest, of human industries—is still unrealized by the educated classes.

1. **Comprehensive Official Publications.**—Under this head may be mentioned the first volume of the Butterflies of India by Colonel C. T. Bingham, published by His Majesty's Secretary of State for India; the

eleventh fascicle of the Illustrations of the Zoology of the "Investigator," published by the Director of the Royal Indian Marine; and the Report on the "Investigator" Holothurioidea by Messrs. R. Koehler and C. Vaney, and the Catalogue of the Indian Paguridæ by Major A. Alcock, published by the Trustees of the Indian Museum.

2. **Unofficial Monographs** include 5 parts of Mr. F. Moore's Lepidoptera Indica; the important Monograph of the *Anopheles* Mosquitoes of India, by Captains S. P. James and W. G. Liston; and an instalment of Mr. Stanley Gardiner's Fauna and Geography of the Maldive and Laccadive Archipelagoes, dealing with Cephalopods, parasitic worms, and several groups of Coelenterates, Crustaceans, and Insects. Here too may be mentioned, as being within our scope, though outside our official reckoning, the second and third parts of Dr. W. A. Herdman's Report on the Pearl Oyster Fisheries and Marine Biology of Ceylon; and several Reports of the German Deep Sea ("Valdivia") Expedition which, in its course, crossed the Arabian Sea and the Bay of Bengal.

3. Short Papers and Serials.

1. **Mammals.**—The *Journal* of the Bombay Natural History Society contains a paper by Colonel A. E. Ward on the small mammals of Kashmir, and one by Mr. R. C. Wroughton on the common striped Palm-squirrel. In the *Annals and Magazine of Natural History* a new vole from Kashmir is described by Mr. J. L. Bonhote, and a new squirrel from Burma by Mr. Oldfield Thomas, F.R.S. Mr. R. Lydekker, F.R.S., has contributed notes on the Gorals of India and Burma to the *Zoologist*, and a paper on Dolphins from Travancore to the *Proceedings* of the Zoological Society. Finally in the *Zoologischer Anzeiger* Dr. Hilzheimer publishes some critical notes on the tiger-skulls in the Strassburg Museum.

2. **Birds.**—In the *Journal* of the Bombay Natural History Society the avifauna of Darbhanga by Mr. C. M. Inglis, and that of Travancore by Mr. H. S. Ferguson, are continued; Captain H. T. Fulton publishes notes on the Birds of Chitral, and Mr. D. Dewar on those of Madras; and Mr. E. W. Oates describes some new species of Silver Pheasants from Burma. Three new species of birds from Tibet are described by Mr. H. E. Dresser in the *Proceedings* of the Zoo-

logical Society; and in the *Indian Forester* Mr. F. Finn concludes his account of the Indian Pheasants.

3. **Reptiles** and **Amphibia**.—Dr. N. Annandale has published several papers in the *Journal* of the Asiatic Society of Bengal under the titles "Contributions to Oriental Herpetology" and "Additions to the Collection of Oriental Snakes in the Indian Museum," and has also contributed Notes on some Oriental Geckos to the *Annals and Magazine of Natural History*, and Descriptions of abnormal Ranid larvæ from North East India to the *Proceedings* of the Zoological Society. In the *Journal* of the Bombay Natural History Society there are to be found descriptions of three new species of snakes from Upper Burma, in papers by Mr. G. A. Boulenger, F.R.S., and by Captain F. Wall, and copious notes by the latter author on the snakes of Cannanore and Bangalore. Mr. Boulenger also describes, in the *Annals and Magazine of Natural History*, some reptiles and batrachians from Tibet. In the *Proceedings* of the Zoological Society Mr. F. E. Beddard, F. R.S., discusses the visceral anatomy of the sea-snakes *Hydrus* and *Platurus*. Finally, the *Zoologischer Anzeiger* contains an important paper by Dr. Roux, entitled "La Famille des Ranidæ," in which the Indian genera established since the publication of the volume on Reptiles and Amphibia in the Fauna of British India are tabulated.

4. **Fishes.**—Some new Cyprinoid Fishes from Tibet form the subject of two papers in the *Annals and Magazine of Natural History* by Mr. C. T. Regan, and the same author gives an account of the Fishes of the Persian Gulf in the *Journal* of the Bombay Natural History Society. A new genus of Teleostean fishes allied to *Chiasmodus* is also described by Captain MacGilchrist in the *Annals*. Mention must here be made of Dr. W. G. Ridewood's important papers on the cranial osteology of the *Notopteridæ*, published in the *Journal* of the Linnean Society, and on that of the Clupeoid Fishes published in the *Proceedings* of the Zoological Society, although they go beyond the Indian fauna in their reach. It is convenient, too, to notice here a paper by Mr. G. H. Parker in the *Bulletin* of the Museum of Comparative Zoology of Harvard, on the Maldive *Cephalochorda*.

On the whole, as the four preceding paragraphs show, our knowledge of Indian Vertebrates has not been much increased during the last 10 months, and workers, with few exceptions, have kept to the beaten track. Nor is it easy to see how any great progress can be made, locally, until the educated classes of the country begin to show an interest in comparative anatomy and embryology, and in that experimental biology which in Europe already promises to discover something of the laws of heredity, and so to throw further light upon the origin of species and the production of useful breeds, and to point out rational paths to would-be reformers of the human race.

5. **Mollusca.**—The record consists of two papers: one by the late Dr. W. T. Blanford F. R. S., on Indian and Burmese Land-shells, published in the *Proceedings* of the Zoological Society; the other by Mons. A. Bavay, entitled "Espèces Nouvelles du Genre Pecten provenant de L'Indian Museum," published in the *Memoirs* of the Zoological Society of France. The account of the *Cephalopoda* in Mr. Stanley Gardener's Monograph, and Dr. Herdman's Reports on the Pearl Oyster have already been referred to.

6. **Insecta.**—Excluding the special subject of Economic Entomology, and the three monographs before mentioned, I find 28 sets of of papers recorded, a minority of which are to be credited to workers now resident in India. The Earwigs of the Indian Museum Collection are described by Mr. M. Burr in the *Journal* of the Asiatic Society of Bengal. In the *Journal* of the Bombay Natural History Society Sir George Hampson's supplement to the Moths of India, Mr. G. C. Dudgeon's descriptions of Indian and Burmese Moths, and Major G. C. Nurse's descriptions of Indian Hymenoptera, are continued; while Mr. E. H. Meyrick, F.R.S., contributes a paper on Indian Microlepidoptera, and Mr. E. C. H. Young, one upon Bombay Orthoptera. The Royal Society's *Proceedings* contain a note by Majors Adie and Alcock on the occurence of *Anopheles Listoni* in Calcutta. Colonel J. M. Fawcett, in the *Proceedings* of the Zoological Society, writes briefly on Butterflies of the N. E. Himalayas. In the *Transactions* of the Entomological Society there are papers by Dr. N. Annandale on the egg, the early larval stages, and the Hymenopterous parasite of a Coreid bug, and by Mr. G. B. Longstaff on the Butterflies observed

during a tour in India and Ceylon. Entomological contributions to the *Annals and Magazine of Natural History*, include descriptions of Oriental Aphodiid Coleoptera, by Mr. G. J. Arrow; of new Sphegid and Ceropalid Hymenoptera, by Mr. P. Cameron; and of new Eastern Heterocera in the British Museum, by Colonel C. Swinhoe. In the *Proceedings* of the United States National Museum for 1904 a paper by Mr. E. B. Williamson, on the Dragonflies of Burma (and Lower Siam), must be noticed. Two papers by Mr. C. Ritsema, in the *Notes* of the Leyden Museum, upon the species of the Coleopterous genus *Helota*, refer more or less to India. In the *Bulletin* of the Paris Natural History Museum Dr. Max Hagedorn enumerates the Scolytid beetles of Sikkim (and Japan), and Dr. Joanny Martin describes a new genus of the *Natalicolaria* group of Hemiptera from India. The *Revue d'Entomologie* for 1904-05 contains several papers of importance to India, namely upon exotic Staphylinid beetles, by Mons. A. Fauvel, and upon the Enoplotrupes and Geotrupes beetles of Asia by Mons. A. Boucomont. To the *Annales* of the Belgian Entomological Society for 1904-05 Mr. Martin Jacoby contributes a long account of Indian Phytophagous Coleoptera; Mons. J. Bourgeois' descriptions of 4 new species of *Lycides* (Coleoptera) from Bengal; and Mons. A. Forel, under the heading *Miscellanea Myrmecologiques*, a short account of the ants of the Nicobars. Finally, in the *Biologisches Centralblatt* for 1905, Dr. F. Doflein publishes some observations on the leaf-nesting ant, *Oecophylla smaragdina*.

7. **Arachnida** and **Crustacea**.—Dr. Karl Kraepelin's Geograpische Verbreitung der Scorpione, published in the *Zoologischer Anzeiger* for 1905 is of great importance to the student of the Indian fauna. In the *Journal* of the Asiatic Society of Bengal Mr. E. Vredenberg notes the occurrence of *Apus* in Baluchistan. In the Smithsonian Miscellaneous Collection Quarterly Issue 1905, Mr. N. S. Jambunathan gives an account of the habits and Life History of a Social Spider (*Stegodyphus sarasinorum* Koch). To the *Annals and Magazine of Natural History* Captain A. C. MacGilchrist contributes an account of new and rare Decapod Crustacea dredged by the R. I. M. S. "Investigator," and Major A. Alcock a description of a new species of the Dorippoid genus *Cymonomus*, and a discussion of the distribution of the

Dorippidæ and its possible bearing upon a problem of past geography.

8. **Vermes.**—Dr. Annandale, in the *Journal* of the Asiatic Society of Bengal, has described a new species of *Chætogaster* commensal with a pond-snail. In the *Bolletino* of the Zoological Museum of the University of Turin for 1904 Signor Camerano gives an account of a new species of Gordiid from Upper Burma, and in the Systematic part of the *Zoologische Jahrbucher* for 1905, Dr. Klein has a paper on the parasitic flukes of one of the common Indian frogs (*Rana hexadactyla*).

9. **Cœlenterata.**—Dr. Annandale, in the *Journal* of the Asiatic Society of Bengal, has a short note on the Hydra found in the Calcutta tanks. In the *Annals and Magazine of Natural History* Professor Arthur Thomson and Dr. Henderson publish a preliminary notice of the Deep-Sea Alcyonaria dredged by the R. I. M. S. "Investigator;" while another Zoologist of the Aberdeen University, Dr. J. J. Simpson, contributes to the *Zoologischer Anzeiger* a full description of a new type of Siphonogorgid Alcyonarian from the "Investigator" collections.

10. **Protozoa.**—Besides some papers of purely pathological interest, the "Scientific Memoirs" contain an account of a parasite found in the white corpuscles of the blood of dogs, by Captain S. P. James, I.M.S., and a study of *Hæmogregarina gerbilli*, by Lieut. S. R. Christophers I.M.S.

11. **Miscellaneous.**—Here may be mentioned an interesting and suggestive paper by Captain W. G. Liston, I.M.S., upon the connection between plague, rats, and fleas, which appears in the *Journal* of the Bombay Natural History Society.

The Natural History Section of the Indian Museum.—The institution has been enriched (1) by the purchase of a large and well-arranged collection of Moths, brought together during 20 years' residence in India by Mr. G. C. Dudgeon; (2) by a further consignment of rare material collected by the R. I. M. S. "Investigator;" (3) by numerous specimens of the fauna of Seistan and its vicinity, collected by the officers of the Seistan Arbitration Commission under Col. A. H. McMahon, C.S.I., C.I.E.; and (4) by a very select and well-preserved lot of material—including a fine male dugong—from the Madura

District, collected by Dr. N. Annandale while on special deputation for the purpose. Also, thanks to the friendly co-operation of European naturalists, much progress has been made in the work of systematizing the collections, and numerous groups—including small Mammals, Mollusca, Insects, Entomostracous Crustacea, Echinoderms, Coelenterates, and Planarians—have been entrusted to experts in England and on the Continent to be named and described. The Museum has also continued to co-operate with the kindred institutions of Europe in freely exchanging desiderata.

The publications of the Museum have already been mentioned, and several others are in progress, of which the most important are the following:—(1) a report, by Professor Arthur Thomson and his assistant Dr. Henderson, on the "Investigator" Alcyonarians; (2) a report, by Messrs. R. Koehler and C. Vaney, on the "Investigator" Echinoids; (3) a report, by Mr. E. A. Smith, I.S.O., on some "Investigator" Deep-Sea Mollusca; (4) a report, under the superintendence of Professor L. Joubin, on the Oriental species of Arca in the Indian Museum; and (5) another instalment of the Catalogue of Decapod Crustacea by Lt.-Colonel A. Alcock.

Reviewed as a whole, the present condition of Zoological Science in India, depending so much as it does upon spasmodic amateur effort at home and upon casual expert assistance from abroad, is very far from satisfactory. The essential requisites to further progress are:—

(1) An organized zoological survey, chiefly directed towards collecting and observing those forms of invertebrate life—prodigious in number and fertile in every kind of interest—which are neglected by the amateur.

(2) A considerable increase of the trained staff of central museums of reference like the Indian Museum.

(3) The establishment of zoological laboratories and small teaching museums in all the large university-colleges of northern and western India, with professors in charge whose sole duty should be to teach, and to conduct research.

Until something of this kind is done, zoology in this country can hardly be anything more than a pastime of a few peculiar spirits, as it was in Europe about 100 years ago.

AGRICULTURAL ENTOMOLOGY.

BY

H. MAXWELL-LEFROY, M.A., F.E.S., F.Z.S.

Entomologist to the Government of India.

Study of Insect Pests of Crops.—The study of the insect pests of Indian crops has been continued by Mr. H. M. Lefroy, M.A., F.E.S., F.Z.S., Government Entomologist, and by provincial assistants under his control. The common pests of the more important crops have been investigated and their classification and life-histories worked out, more particularly those of Behar, where the head-quarters of the Government Entomologist are located at the Pusa Research Institute. The more important results have been published in a series of leaflets, dealing with some injurious insects and practical remedies against their attacks. A special inquiry was concluded into the Insect Pests of Coffee.

The Bombay Locust.—(*Acridium succintum*). A severe plague of Bombay Locusts in 1904, which caused great damage, led to a special investigation of this pest by Mr. Lefroy in conjunction with the Bombay Department of Agriculture. The full life-history of this locust was investigated for the first time, and measures for its destruction were devised and carried out on a large scale. A report giving a complete account of this inquiry will shortly be published.

Tea Pests.—An investigation of the most serious insect pest of tea, known as mosquito blight and caused by a plant bug (*Helopeltis theivora*) has been made by Dr. H. H. Mann, D.Sc., Scientific officer of the Indian Tea Association, with the result that a method of cure has been devised, which has been successful under suitable conditions. Dr. Mann has published two bulletins on "The Mosquito Blight of Tea", and a third is now in the press.

Sericulture.—The Bengal Silk Committee, who are assisted by a Government subsidy, have continued their efforts to induce the mulberry silk rearers to use only healthy seed examined by the microscope under the Pasteur system, a special establishment being employed at silk rearing depôts, where classes are held. This work is reported to have achieved some results, rearers

now appreciating the necessity for healthy seed and the use of the microscope. Some experiments have been made in Assam with imported French and Italian seed with successful preliminary results. Seed was distributed to some rearers, who obtained good returns. Examination revealed the existence of *pebrine* and *flacherie* in the moths, so that reliance must be placed upon imported seed until local arrangements are made for rearing healthy seed. A special inquiry was made into the indigenous tasar silk industry of Bengal and the Central Provinces by Mr. N. G. Mukerji, M. A., M.R.A.C., F.H.A.S. The decaying state of the industry was found to be mainly due to the prevalence of the *grasserie* disease, which has become widespread since the rearers have taken to using home-bred seed instead of collecting wild cocoons from the forest. (Report on the inquiry into the state of the Tasar Silk Industry in Bengal and the Central Provinces of India.) Some important work has been accomplished at Mr. Tata's private Silk Farm, Bangalore, under the charge of a Japanese expert, who is testing the adaptability to India of Japanese methods of mulberry cultivation, silk worm rearing and silk reeling. The Government of India have sanctioned the establishment of a similar silk farm at the Pusa Institute.

Systematic Entomology.—Progress has been made with the Insect Survey of India, carried on in co-operation with the Indian Museum, Calcutta. Collections were made, classified and sent to Specialists for identification. The result of their investigations are being published in the United States and Europe.

FOREST ENTOMOLOGY.

BY

E. P. STEBBING, F.L.S., F.Z.S., F.E.S.

Forest Entomologist to the Government of India.

(1) The work of the Forest Entomologist, whilst on furlough, was carried on at the Natural History Museum in London and from thence an official visit was paid to some of the chief Forest Colleges and Museums on the Continent. At the same time work was continued in

connection with the Volume on the *Buprestidæ* for the " Fauna of British India." At the Natural History Museum identification work in connection with the collections already made, as well as of specimens received from India, was carried on, while during April and June the Forest Colleges at Eberswalde, Tharandt, Aschaffenberg, Munich, St. Petersburg, Vienna and Nancy were visited, as well as the Natural history Museums of Brussels, Berlin, St. Petersburg, Dresden, Munich, Vienna, Genoa and Paris.

2. The Chief Economic results of the year are given below :—

(a) By the Forest Entomologist the life history of an undescribed species of *Sphærotrypes*, a Scolytid bark borer of very considerable economic importance in the Sal areas of the Siwaliks, was nearly completed by observations carried out in the autumn.

The controversy regarding the period of ripening of the cones of *Pinus longifolia* was brought to an end by the discovery that some of the so-called cones were galls made by the grubs of a Cecidomyid fly.

A tour in Burma resulted in the discovery of the insect which produces the so called " bee holes " in teak timber. It proved to be the larva of the moth *Duomitus ceramicus*. " Bee hole " teak timber has been the cause of complaints from the British Admiralty and Timber Merchants at Home from the earliest days of teak export work at Moulmein (1820).

Further investigations were made into the life-histories of the teak defoliators *Hyblæa puera* and *Pyrausta machœralis*, and also into the habits of a number of Scolytidæ and various predaceous and parasitic insects, mostly new to science.

A series of experiments were conducted at the Indian Museum (during 1905) with the object of discovering a preservative against the attacks of the bamboo beetles or shot borers (*Dinoderus*). Soaking first in water, then in Rangoon oil, was found to be effective even after lengthy trial on field service as telegraph posts.

(b) By other departmental investigators. Other officers of the Department carried out important investigations. Mr. S. Carr, F. C. H., continued his observations on the life-history of *Hyblæa puera* in the Rangoon Teak Plantations and succeeded in discovering where the

eggs are laid by the moth and how and where the young larvae spend their first stages.

In Madras the serious attack of the larvæ of *Arbela tetraonis*, the Casuarina bark eating insect, which commenced in 1903, was only brought to an end by modifying the provisions of the working plan for some of the Ganjam plantations and cutting out the greater number of the trees. Mr. Latham reported this pest from South Canara on the west coast.

Mr. P. M. Lushington reported several injurious insects of *Swietenia Mahogani* at Nilumbar.

Investigations were also conducted in the United Provinces on the habits of defoliating pests of the Sal, Haldu (*Adina cordifolia*), *Careya arborea*, *Wrightia tomentosa* and *Cassia Fistula*. These are still proceeding, as also are others into teak-leaf galls and insects infesting the seed in Bombay forests, Cynipid and lepidopterous pests in the fruit of *Terminlia Chebula* in Berar and Sal wood borers and leaf defoliators in Assam.

(c) By other observers. As usual important investigations were carried out by non-departmental observers. The Political Agent, Zhob, reported in 1903 that the Chilgoza (*Pinus Gerardiana*) trees in the Shinghar forests were dying off under what appeared to be attacks of insects. From the descriptions received the insects appeared to be Scolytidæ, and the subsequent receipt of a section of a stem with the bark on confirmed this diagnosis. It was arranged that Shinghar should be visited shortly after the close of the year under report in order to prescribe preventive measures against this attack.

Reports were also received that the avenue trees in Quetta were suffering severely from the attacks of insect pests, and during the year under report it was discovered that this insect was a longicorn beetle. The Agent to the Governor-General called for a report on this pest, and a note was prepared by the Superintendent of Arboriculture. The importance of this subject justified a more careful investigation on the spot, the result of which is embodied in a note published after the close of the year.

As in former years the Reporter on Economic Products to the Government of India assisted in this study and forwarded specimens

of four different kinds of beetles found in tunnels in the wood of *Poinciana elata*. Two were wood boring insects, the others predaceous upon them and their grubs.

In accordance with suggestions made when considering the life history of *Pyrausta machæralis* Mr. Bourdillon, Conservator of Forests, Travancore State, submitted valuable quarterly reports on the dates of appearance, amount of defoliation done by, etc., the defoliating insects *Hyblæa puera* and *Pyrausta machæralis*.

3. The chief Scientific Results of the year's work are set forth below.

The discovery of the insect forming the celebrated "bee holes" in Teak in Burma is as interesting scientifically as economically, since *Duomitus ceramicus* had never been previously reported from Burma in spite of its evident great abundance in some localities.

The Cecidomyid gall producer of the *Pinus longifolia* must also be considered an investigation of considerable interest, as both the Cecidomyid and the Chalcid, *Trigonomerus* sp., parasitic upon it are new to science. The beetles mentioned as boring into Poinciana proved to be *Heterobostrychus æqualis* and *Dinoderous punctatissimus*, this being the first information received as to the food of the latter.

Amongst purely literary work the preparation of the Buprestid Volume, in which new Indian species are described, and descriptions of new species of Scolytidæ (*Sphærotrypes*, *Cryphalus*, *Grossotarsus* and *Diapus*) in No. 3 of Departmental Notes may be mentioned. Of this family a special study is being made, as there are but few specialists in the group and practically none to work out the Indian species.

Not yet issued.

Valuable help in the identification of insects was received from Sir George Hampson and Messrs. Waterhouse, Gahan and Arrow of the British Museum Staff, from Colonel C. T. Bingham, Messrs. G. Lewis, Distant and Dudgeon, from M. P. Lesne of the Paris Museum and Dr. L. O. Howard, Chief of the Entomological Bureau, and Dr. W. H. Ashmead of the Museum, Washington. A list of publications is appended.

Publications.

(1) Casuarina bark-eating Caterpillar (*Arbela tetraonis*) by Mr. C. E. C. Fischer, *Indian Forester*, Scientific papers, xxxi, pp. 9-18 (1905).

(2) Insects pests of Swietenia Mahogani, by Mr. P. M. Lushington *Indian Forester*, Scientific Papers, xxxi, pp. 74-75 (1905).

(3) A volume on Indian Cerambycidæ for the "Fauna of British India" by Mr. C. J. Gahan of the British Museum. (*Under preparation*).

(4) On the life-history and habits of the moth *Duomitus leuconotus* in Calcutta by Mr. E. P. Stebbing, *Journal Asiatic Society Bengal*, lxxxiii, Part II, pp. 25-30 (1904).

(5) A Note upon the larva of *Clania Crameri*. Read before the Linnean Society of London in April 1904 by Mr. E. P. Stebbing.

(6) A note upon the identification of the Insects reported by Mr. Lushington as injuring Swietenia Mahogani by Mr. E. P. Stebbing. *Indian Forester*, Scientific Papers, xxxi, pp. 75-76 (1905).

(7) The Volume on *Indian Buprestidae* by Mr. E. P. Stebbing. (*Under preparation*).

(8) Departmental Notes on Insects that affect Forestry, No. 3, by Mr. E. P. Stebbing.

(9) Manual of Indian Forest Zoology. A revision of a portion of the proof was undertaken.

(10) A "Note upon the Bee hole borer of Teak in Burma (*Duomitus ceramicus*)," by Mr. E. P. Stebbing.

(11) Insect life in India and how to study it, by Mr. E. P. Stebbing *Journal of the Bombay Natural History Society*, Volume xvi, p. 115 (1904).

VETERINARY SCIENCE.

BY

A. LINGARD, M.B., M.S., D.P.H.

Imperial Bacteriologist to the Government of India.

Sero-therapy.

In the Laboratory at Muktesar, during the year 1904-05, the preparation of anti-rinderpest and anthrax sera continued and quantities considerably in excess of former years were prepared.

In addition, Hæmorrhagic Septicæmia serum, which had been worked out in 1902 but could not be issued on account of the impossibility of obtaining fresh virulent material, was for the first time prepared in quantity and issued to Superintendents.

Further, Mallein, which was made at the Laboratory in 1899, but which had to be discontinued after the destruction of the Laboratory by fire, was again prepared and issued during 1904.

The following table gives the various quantities of different sera, etc., prepared and issued during the 12 months under review, together with the increase, comparing it with the quantities issued during the previous year :—

Name of sera.	Quantity prepared.	Quantity issued.	Increased manufacture as compared with last year.
	c. c.	Doses.	Doses.
Anti-Rinderpest serum	813,352 or 151,855 (doses.)	130,810	29,794
Anti-Anthrax serum	137,355 or 27,471 (doses.)	22,391	19,468
Hæmorrhagic Septicæmia serum . .	15,665 or 3,135 (doses.)	...	...
Mallein	1,514 (doses.)	675	...

During the year 590 outbreaks of Rinderpest were dealt with and 56,483 animals were immunized with serum by the "serum alone" method. Of this number, after injection, 263 succumbed, representing a mortality of 0·46 per cent.

One hundred and eighty-seven (187) outbreaks of Anthrax were dealt with and 21,287 animals were immunized with the anti-Anthrax serum. Not a single death followed the inoculations.

With regard to the use of Hæmorrhagic Septicæmia serum in the field, satisfactory reports have been received and the demands for it are increasing daily.

The utility of the various kinds of sera has been officially recognised, as conferring considerable benefit on the agricultural community; and each year sero-therapy in India is gaining ground and is generally being appreciated by the zemindars.

BACTERIOLOGY.

Rinderpest.—Experiments were initiated and continued with a view to the production of a prophylactic capable of conferring immunity on bovines, etc., without the necessity of hyper-immunization with large quantities of blood. When satisfactory results have been obtained, the same will be communicated to the Government.

Dry Serum.—The utility of serum in dry form was tried in the field and results were satisfactory. The advantage in favour of dry serum is that it can be distributed in much smaller bulk, but as no antiseptic can be added to this in dry form, the powder must be used within 24 hours after solution has been made. Probably the dry form can only be used in this country under the direct supervision of Superintendents. The greatest use of this dry serum will most probably be found to be in the case of expeditions, military or otherwise, where large numbers of transport animals are employed.

Further, such expeditions carrying dry serum with them might have an opportunity of treating the cattle of people in whose territory they happened to be passing through or visiting; and by such demonstrations their sojourns might be more acceptable and political relations with such people facilitated. At the same time, should arrangements

be made by Government with any other foreign country to supply them with any particular serum or sera prepared at Muktesar, the dry material would be the best form for transmission to them.

Rinderpest in Camels.—The results of experiments proved that camels were susceptible to inoculated bovine Rinderpest and *vice versâ*. As a rule, the disease was of a mild type and recovery followed in each case.

Pyroplasmosis Trypanosomiasis and Malignant Œdema in Cattle.—These diseases are only of occasional prevalence and will be dealt with in detail as opportunity occurs. Much work has already been done with regard to the above-mentioned diseases, and special reports dealing with each individually will be submitted in due course.

Surra.—The different questions as suggested in the programme of work for the past year have been dealt with *seriatim*, and considerable progress made in the various lines of research, which are still being continued.

It is hoped that the report on Trypanosomiasis in camels will be submitted at the close of the present official year. Short notices concerning the advancement made with regard to the various questions respectively taken in hand have been recorded in the Annual Report for 1904-05.

Dourine.—A full and detailed account has been published with regard to this disease in various breeds of horses, etc., and material is now accumulating for a further report to be submitted in the near future.

Training of Officers and Veterinary Assistants.—Four officers of the Army Veterinary Department and Civil Veterinary Department attended post-graduate classes during June to September inclusive, and in addition 67 Veterinary Assistants were instructed in the various practical and theoretical methods of inoculation and serum therapeutics.

Examination of Specimens.—Reports were forwarded to the officers concerned with regard to 124 specimens of different kinds of pathological material received at this Laboratory for microscopical examination and diagnosis during the year.

During the year, the Imperial Bacteriologist published:—

(i) Report on the preparation of Rinderpest protective serum.

(ii) Report on Dourine in different breeds of equines.

(iii) Annual Report.

(iv) Observations on the Filarial Embryos found in the general circulation of the Equidæ and Bovidæ and their probable pathological significances. Fasciculus I. Bursati (published by Messrs. Adlard and Son, London).

The following papers were published by the Imperial Bacteriologist in the Scientific Journals :—

(*a*) A short account of the various trypanosomata found to date in India in the blood of some of the lower animals and fish. (I. M. G., Vol. xxxix, No. 12.)

(*b*) The giant trypanosoma discovered in the blood of bovines (Centralblatt für Bakteriologie, Parasitenkunde und Infek: Originale, Band xxxv).

(*c*) Can the Piroplasma Bigeminum find a habitat in the human subject? (Centralblatt für Bakteriologie, Parasitenkunde und Infek: Originale, Band xxxvi).

(*d*) The trypanosoma of Dourine and its life-history. (Centralblatt für Bakteriologie, Parasitenkunde und Infek: Originale, Band xxxvii).

(*e*) Resistance against Rinderpest and other infectious diseases conferred by the subcutaneous injection of certain bile products, and also by the injection of substances prepared from animal testes and the seeds of plants. (Centralblatt für Bakteriologie, Parasitenkunde und Infek: Originale, Band xxxvi).

(*f*) A preliminary note on Piroplasmosis found in man and in some of the lower animals. (I. M. G., Vol., No. xxxix.)

Papers published by the Assistant Bacteriologist during the year :—

(*a*) A trypanosoma found in the blood of cattle. (By Captains Durrant and Holmes). Journal of Comparative Pathology and Therapeutics, Vol. xvii, page 209.

(*b*) Evolution of the Trypanosoma Evansi.—Journal of Comparative Pathology and Therapeutics, Vol. xvii, page 210.

(*c*) Some diseases complicating Rinderpest among cattle in India. —Journal of Comparative Pathology and Therapeutics, Vol. xvii, page 317.

Other papers published bearing on such diseases:—

(*a*) The prophylactic treatment of Rinderpest by means of preventive inoculation, more especially considered in regard to the conditions prevailing in India. (By Captain G. K. Walker.) Comparative Pathology and Therapeutics, Vol. xvii, page 326.

(*b*) "On Dourine." (By Captain F.S.H. Baldrey.) Comparative Pathology and Therapeutics, Volume xvii, page 1.

(*c*) "Dourine and Surra." (By Major H. T. Pease.) Veterinary Journal, November, 1904.

PROGRAMME OF WORK OF THE VARIOUS SCIENTIFIC DEPARTMENTS FOR THE YEAR 1905-06, AS APPROVED BY THE BOARD ON 24TH MARCH 1905.

1. Meteorological Department.

As the two gazetted assistants whose appointment was sanctioned in January 1904 have only recently joined the Department, several items of last year's programme could not be carried out and are accordingly repeated below: as much as possible of the preparatory work has been done.

Daily Forecast, Storm and Flood warning.—It is intended to begin the formation of a classified file of maps on a reduced scale illustrating the principal types of weather: series of charts of all important storms or remarkable disturbances will be inserted for ready reference in determining the probable developments of the weather, and the areas to which storm or flood warnings should be sent.

Study of the Indian monsoon area and seasonal forecasting.—The materials that have been examined during the year support the view that abnormalities in the Indian rainfall are due to unusual elements in the larger circulation of the atmosphere, including deflections in a vertical as well as a horizontal direction. There are decided suggestions of relationship between the conditions in Siberia and the Indian Ocean with those of our monsoon, but the data are still being collected and much work has yet to be done before any results can be regarded as established.

It is now clear that sufficient readings are not available for the publication of a daily map of the whole monsoon area, including Southern Asia, East Africa and Australia: maps of this region showing the monthly departures from normal of pressure and temperature will accordingly be made.

Pilot Charts.—Considerable progress has been made in the preparation of an atlas of monthly charts of the Indian Ocean for use by captains of vessels.

Study of the upper atmosphere: Balloons.—It appears unlikely that over large parts of India an india-rubber balloon sent up with self-registering apparatus would be found and returned to Government after reaching the earth. Hence it is proposed to begin with paper balloons which will be filled with hydrogen and sent up in fairly calm weather. From observations made with two theodolites about two miles apart it should be possible to deduce the wind velocity at different elevations.

Kites.—If the necessary apparatus arrives in time operations will begin, probably at Kurrachee, during the approaching monsoon season. After preliminary experience with hand-winding gear has been obtained, an oil motor will be employed.

Solar Radiation.—Observations made with black-bulb thermometers have long been regarded as unsatisfactory for the purpose of studying variations from year to year in the quantity of heat given off by the sun, and a beginning has been made at Calcutta with a Calendar platinum sunshine-recorder which promises to give much more reliable results. Instruments of the latter type should be started in one or two of our other observatories under suitable conditions, and a satisfactory method of standardising the apparatus from time to time should be obtained and adopted.

Atmospheric Electricity.—Apparatus for measuring the potential gradient of the air by means of a water dropper has been established at Calcutta, as well as apparatus for ascertaining the rate of dissipation of a charge. It is intended to make a study of the differences found between the wet and the dry periods of the year.

Magnetism.—Owing partly to architectural difficulties and partly to slight changes in one of the new magnets, it has been found necessary to continue for another year the duplicate series of observations for the purpose of comparing the conditions at Alibág with those at Colába. The former station is that to which the magnetic observations will shortly be transferred, in view of the approaching establishment of electric tramways at Bombay.

Arrangements have also been made for a discussion of the Colába magnetic observations of the past 60 years.

Astronomy.—The appointment of an assistant at Kodaikánal has been sanctioned, but the date of his arrival is doubtful.

The spectroscopic examination of spots and prominences has now become part of the routine work. The spectroheliograph has been erected and satisfactory photographs of the sun in monochromatic light have already been made with it.

Arrangements have been made for co-operating with the "Committee on Solar Research," a representative body of astronomers with Professor G. Hale as chairman.

2. Survey of India.

The special scientific work which will probably be undertaken by the Survey of India during 1905-6 is as follows:—

Magnetic Survey.—Colába Observatory under the Meteorological Reporter and the four observatories under the Surveyor-General will continue to work: observations will be taken at 24 Repeat Stations: and the preliminary field work will be extended over Assam and Burma.

Solar Photography.—Photographs of the sun will be taken daily at 10 A.M., and 4 P.M., at Dehra Dun, as has been done since 1879 in conjunction with Greenwich.

3. Geological Survey.

The following subjects will probably be undertaken:—

1. Investigation of the copper-sulphide belt of the Singbhum district.
2. Survey of the auriferous gravels of the Upper Irrawaddy.
3. Exploration of the Upper Chindwin Basin
4. Survey of unmapped areas in the Central Provinces.
5. Continuation of mapping in unsurveyed parts of Central India and, in conjunction with it, a survey of the Aravalli series in the adjoining parts of Rajputana.

Extension of survey work in progress in the Northern Shan States.

4. Botanical Survey.

I.—Country under the Superintendent of the Royal Botanic Garden, Calcutta.

(*a*) *Bengal.*

It is proposed to utilise the agency of trained Lepcha collectors under the supervision of the Officer in charge of the Chumbi Valley Road Survey to collect in that valley, and it is hoped to be possible to send a European collector also for a short time. An endeavour will be made to adhere to the plan of working out for some one district in Bengal its flora as has been done for the Hughli, Howrah and Sundarbuns districts, but this will depend on whether a European collector will be available or not.

(*b*) *Assam and Burma.*

The same policy will be followed in prosecuting the systematic survey of Assam and Burma.

II.—Survey of Bombay.

Professor Gammie, the Officer in charge of the survey of Western India, proposes during the year 1905-06 to continue special investigations on the Ghâts, some of the Deccan districts, Gujarat and, possibly, Sindh.

III.—Survey of Southern India.

The Government Botanist, Madras, will undertake during the year 1905-06 a tour in Travancore and a tour in the Ceded Districts. These tours were fixed for the current year 1904-05, but had to be postponed owing to the economic exigencies of the Madras Government. This programme has received the approval of the Board of Revenue, Madras.

IV.—Economic Investigations.

The only economic work which comes directly under the cognizance of the Director of the Botanical Survey is that done by himself in his capacity as Superintendent of the Royal Botanic Garden, Calcutta.

The Officiating Director proposes to take up and continue, as far as his other duties will permit, the study of the botanical classification of the various kinds of fibre-yielding plants grown in India. Those Indian fibres are also being studied by the Agricultural Department as field crops, while the commercial value of their produce is being investigated by the Reporter on Economic Products. The Economic investigations which form by far the greater part of the work of the other two officers of the Botanical Survey are directly instituted and controlled by their own Local Governments, and do not come under the cognizance of the Director of the Botanical Survey.

5. Agricultural Department.

1. Pusa Research Institute, Agricultural College and Experimental Farm.—Further progress will be made in establishing the Pusa Agricultural Research station. Some of the buildings are approaching completion. The existing staff of experts will be transferred there as soon as the quarters are ready, and the newly appointed Specialists will be instructed in their lines of work. The College and Laboratories will not be ready till 1906-07. The Farm buildings have been built and a substantial portion of the land has been broken up, but it has not yet been brought into a sufficiently good cultivable condition to admit of a comprehensive scheme of experiments during the coming year. The principal crops that will be grown are cotton, sugarcane, indigo, rice, tobacco, linseed, til, maize, wheat, gram, mustard, groundnut and fodder crops. In growing these crops, the main objects will be to determine:—

(*a*) the effect of transferring varieties from district to district;
(*b*) the effects of different methods of cultivation, and the value of different manures;
(*c*) the effect of acclimatization upon indigenous and exotic varieties;
(*d*) improvement by cross fertilization and selection.

Crops that already have proved successful will be grown on a larger scale for seed distribution. The Java-Natal variety of indigo will thus be grown for seed distribution. The best varieties of sugarcane and rice grown in different parts of India will be tested for Behar A

number of varieties of American, Java and Sumatra tobaccos are under trial. An experiment will be tried in growing linseed for flax. A mulberry plantation has been started for experiments in sericulture. A commencement will be made with the vegetable plots and fruit orchards, where ultimately experiments will be made for improving the best varieties. The cattle-breeding farm for the Bengal breed has been started. An experiment is also being made with the acclimatization of Montgomery cattle for milch purposes. Fodder crops will be grown for the cattle, and attempts will be made to improve the pastures by the trial of several kinds of grasses.

2. Provincial Experimental Farms.—At all the provincial farms there are series of permanent experiments dealing with the trial of manures for various crops, irrigation, crop rotations, methods of cultivation, testing of varieties of crops and the like. In Bombay the number of experiment stations has been increased to nine, largely devoted to cotton, wheat, groundnut and juar. A systematic study of the varieties of some principal crops is in progress under Professor Gammie. The Poona Dairy Farm will be continued, including tests of the milking qualities of several breeds, and the comparative trial of various fodder crops. Many of the problems connected with sugarcane are under study at the Manjiri Farm. Experiments with the effluent of sewage passed through a septic tank are in progress at the sewage Farm, (1) to find out the best treatment for its purification; (2) to find out the manurial value of the effluent and the varieties of crops that can best be grown with it; and (3) to find out the area of land required to take the sewage from a given population. Problems (2) and (3) are practically solved. Experiments are in progress at the Botanical Gardens, Ganeshkhind, to test rubber, fibre and medicinal plants, and to improve and increase the yield of fruit trees. The Department of Agriculture in the United Provinces will pay special attention to the study of juar, irrigation wells and sugar manufacture. Cawnpore is the principal centre of experiments with wheat rust. In Bengal, attention is mainly devoted to rice, sugarcane, tobacco and potatoes. A special enquiry into the cultivation and manufacture of indigo is in progress in Behar under Mr. Bergtheil, Bacteriologist. Another special enquiry is being conducted by Mr. Finlow, Chemist, into the cultivation and alleged deteri-

oration of jute. In the Punjab, wheat and cotton are the principal crops under investigation. A large seed farm will be started. The Madras farms are specially concerned with cotton, sorghums, sugarcane, tobacco and groundnut. The study of wild peppers will be taken up with reference to the pepper-vine disease. A survey of the cultivated plants has been started. Attention is being given to agave fibre plants. In the Central Provinces, the principal crops under experiment are cotton, juar, rice and wheat. The Assam Department is concerned mostly with potatoes, fodder crops, spices, drugs and tropical fruits. Experiments are also in progress for the introduction of European and other semi-temperate fruits.

3. Agricultural Chemistry.—The Agricultural Chemist to the Government of India will be employed mainly upon the investigation of the following problems:—

(*a*) **Soils.**—The amount of readily available plant food in various Indian soils, with special reference to Dr. Dyer's method of determining the amount of readily available phosphate and potash, has been experimented upon in the Laboratory and the potculture house during the past year, and the subject will be prosecuted further in the current year.

(*b*) **Rain-water, Dew and Drainage water.**—Specimens of these have been collected at Cawnpore and (of rain-water) at Dehra, and the quantity of combined nitrogen determined and reduced to pounds per acre. It is proposed to construct some drain-gauges at Pusa during the current year in order to supplement the Cawnpore records.

(*c*) **Water in soils.**—An attempt will be made to obtain information regarding the nature of the movements of water in Indian soils both under crops and bare fallows. It is also proposed to keep a record of the actual amount of water in the soil at all depths down to 5 feet from the surface.

(*d*) **Cyanogenesis in plants.**—It is proposed to prosecute an enquiry into the glucosides capable of yielding hydrocyanic acid, and more particularly into the poisonous qualities of sorghum, cassava, Rangoon beans, dal (*Dolichos Lablab*) and field peas.

(*e*) The analytical work regarding Indian food-grains and fodders and of samples of other products and manures will be continued.

(*f*) The enquiry into the sugarcane cultivation of the Central Provinces will be supplemented by the analysis of the juice of the different varieties. The results hitherto obtained show that the cane is undoubtedly poor in some parts.

4. Mycology.—The programme of work of the Cryptogamic Botanist to the Government of India is as follows:—

(*a*) It is proposed to continue the work connected with the rusts of wheat and barley. The experiments will mainly be made at Cawnpore (United Provinces), Hoshangabad (Central Provinces), and Lyallpur (Punjab), *first* to collect all the local varieties of wheat true to type, *second* to expose them to conditions favourable to rust by heavy irrigation, *third* to grade the varieties according to their rust-resistant quality, and *fourth* to raise rust-resistant varieties of good milling quality by hybridization.

(*b*) The study of the wilt disease of Arhar (pigeon-pea), and the pepper-vine disease, both of which are caused by the same fungus, will be continued with the object of discovering resistant varieties.

(*c*) Treatment of oat-smut with formaline and copper sulphate is being tested, and that of the two smuts of juar common in India will be tried during the year.

(*d*) Groundnut disease requires further work which cannot be outlined until the results of this year's experiments are known.

(*e*) The green ear disease of bajra which is due to a new species of *Sclerospora*, and which is common in several provinces, will be studied, but is not likely to be fully worked out in the coming year.

(*f*) The coffee twig disease, which has recently appeared in South India, first in the Nilgiris and later in the Neliampatties, is at present under treatment experimentally. The results

of the different methods tried should be known in the coming year, and, if successful, treatment can be extended.

(*g*) The cause of the *Casuarina* disease in the Ganjam plantation has recently been ascertained, and attempts will be made to prevent its extension.

(*h*) It is proposed to arrange for a local study in the coming year of a rice disease which is locally known as *Chatra*, and which is reported from several parts of Bengal.

(*i*) Work on sugarcane diseases, particularly redrot and smut, will be continued.

(*j*) A preliminary tour will be made in Assam to collect information regarding the fungus diseases prevalent in that province.

5. Entomology.—The Insectory, quarters and other buildings at Pusa will be completed, and crops will be grown for the study of insect pests and the methods of treatment. The Entomologist to the Government of India will carry out the following programme:—

(*a*) The investigation of such crop pests as have not been worked out, and the value of remedies against such pests as have been already studied and will be found to occur at Pusa, will be carried out.

(*b*) An attempt will also be made to deal with every pest for which remedies are already known, with a view to protecting crops and to determining how far and at what cost it is possible to check pests by means within the reach of the ordinary cultivator.

(*c*) In addition there are the following enquiries; (1) the treatment of burrowing insects and white ants; (2) the value and scope of treatment with insecticides; (3) the use of light traps as indicators of approaching pests and as means of destroying flying insects; (4) the insect pests of cattle and domestic animals; (5) the value of trap plants, especially of maize and juari as a trap for moth-borer in sugarcane, and of *bhinda* for cotton pests; (6) the value of special means of increasing beneficial insects (parasites and

predators) which prey upon common pests, and (7), the relation between plant vigour and immunity to special classes of pests.

(*d*) It has been arranged to train men in Entomology for Provincial Departments of Agriculture.

(*e*) Arrangements have also been made for the issue of publications dealing with Entomology.

(*f*) The systematic survey of the Insect Fauna of India will be continued, so far as the stress of other work permits.

(*g*) A separate branch of work connected with sericulture will be started at Pusa.

(*h*) A further trial of the South African locust fungus will be made at Pusa under the joint supervision of the Government Entomologist and the Cryptogamic Botanist.

6. Special Investigations.—Amongst special investigations to be carried out the following may be mentioned:—

(*a*) the use of crude nitre as a manure for certain crops;

(*b*) the use of *sitta* (impure salt) as a cattle food;

(*c*) the use of mineral fertilizers;

(*d*) the cultivation of various fibre plants under varying conditions of soil and climate, and the profitable extraction of fibre therefrom;

(*e*) The experiment of crushing varieties of cotton seed, sent to Hull to test the value of the oil and cake.

The practical training of overseers and fieldmen on the best-managed existing farms and at Pusa will also receive attention.

7. Cotton.—As special attention is being given to cotton by the Imperial Department and some of the Provincial Departments, this subject is treated in a separate paragraph. The botanical examination and classification of all existing varieties, both wild and cultivated, has been completed by Professor Gammie, and the results will shortly be published. The introduction of better varieties and improved methods of cultivation is in progress, the principal lines of work being:—

(1) selection of individual plants, some for quality of fibre, others for largeness of yield;

(2) crossing of one indigenous variety with itself or with a second indigenous variety;

(3) crossing of indigenous varieties with exotics;

(4) introduction and acclimatization of exotic varieties;

(5) distribution of sound and pure seed.

Some hybrids obtained at Surat and the Central Provinces show promising prospects, but selection must be made for two or three years longer in order to fix the type. Some new American varieties have been grown with fair success in Dharwar, but require acclimatization. The trial of Egyptian cotton has given very promising results in Sindh under perennial irrigation. These experiments will be largely extended both on the Government farm and by the distribution of seed to cultivators. Selection of seed of indigenous varieties has not given much result in the United Provinces, but the work in that province will be continued (1) by selection of seed mainly for the improvement of the yield, (2) hybridization, and (3) the trial of the variety known as *bani* cotton. Acclimatized Americans show some promise around Cawnpore. In Madras efforts are being made to test and separate the different varieties of cotton grown in mixtures. Cross-breeding between varieties *inter se* will be started. Messrs. Shaw, Wallace & Co. are making extensive trials of tree-cottons in Bengal. The Punjab Department are obtaining promising results with American varieties, both new and acclimatized. Seed of tested varieties will be distributed to cultivators for experimental trial. In the Central Provinces, experiments are in progress (1) to improve indigenous varieties by seed selection and hybridization; (2) to test acclimatized Americans and arrest their deterioration by cross-breeding with new Americans, and (3) to introduce improved methods of cultivation. In all provinces attempts are being made to obtain, for distribution to cultivators, improved seed of indigenous varieties, by collecting the best samples growing in the cultivators' fields, and brought to the principal cotton markets. Endeavours are also being made to induce the owners of ginning factories to set aside the best supplies and gin them separately for subsequent seed distribution. Proposals will be submitted to Government for (1) the appointment of a special cotton expert to the staff of the Inspector-General of Agriculture to inspect and co-ordinate the

work in all provinces; (2) the strengthening of the expert staff in each province in order that they may be in a position to deal adequately with cotton problems; (3) the establishment of three large cotton farms, one farm in the Surat-Broach cotton tract of Bombay for the improvement of the indigenous variety by selection of seed; one farm in a suitable irrigated tract of the Punjab for the trial of exotics; and one farm in the Central Provinces for the dual purpose of (1) the improvement of the coarse *jari* variety by continuous seed selection, and (2) the improvement of the fine *bani* variety by seed selection, mainly to improve the yield.

8. Irrigation.—Experiments will be started in all provinces to give effect to the recommendations made by the Irrigation Commission in Chapter XI of their report.

9. Publication.—The important subject of Publications will also be taken up, the present proposals being:—

(*a*) an extended issue, by the Imperial and Provincial Departments, of leaflets in the vernacular for distribution to cultivators;

(*b*) the issue of bulletins, by the Imperial and Provincial departments dealing with detailed experiments when they become sufficiently advanced to yield definite results;

(*c*) an annual report of the experimental work of each farm for distribution to persons interested therein;

(*d*) the issue of a quarterly agricultural journal, edited by the Pusa staff, for the use of agriculturists and of the general reader interested in Agriculture, and

(*e*) scientific memoirs, to be issued from the Pusa institute, for papers of a scientific or technical nature.

6. Forest Department.

1. Experiments will continue to be made with the preparation of various tannin extracts, more especially to ascertain the best method by which these extracts can be decolorised so as to render them of more marketable value.

2. It is hoped that the services of an expert will be obtained to conduct practical experiments with reference to the manufacture of wood pulp.

3. Investigations will be made by the Forest Entomologist into the injuries to forest growth caused by various insect pests and the best means to adopt to reduce the damage caused by them.

4. The collection of specimens of timbers and other products will be continued for supply to the Director, Botanical Survey, and Reporter on Economic Products.

5. Seeds of several important indigenous species will be collected and sent to various British Colonies.

6. Further collection and analysis of the latices of rubber-producing species will be made.

7. Economic Products Department.

A classification of the resinous substances known in commerce as "dammar" is being carried out with regard to their sources and chemical properties. The odoriferous gum resins of the myrrh tribe are being investigated, and fresh samples are being collected for this purpose from Bombay.

Experiments with the latices of india-rubber trees and the valuation of rubbers from different economic sources are being conducted in conjunction with the Imperial Institute. The Conservators of Forests of the Pegu and Tenasserim Circles, Burma, are experimenting with the tapping of Parameria trees: and the rubbers, collected under different conditions, will be chemically examined by Professor Dunstan.

The enquiry into the origin and value of Indian fibre plants is proceeding. This enquiry deals with the proposal to estimate the cellulose content of such materials as are considered suitable for paper-making. Rattans (Calamus spp.) and mat-making grasses are being collected.

The survey of Indian-grown cottons will be continued during the year, in communication with the Director of the Botanical Survey and the Agricultural Department.

The following medicinal substances are proposed for investigation by the Indigenous Drugs Committee during the coming year:—Adhatoda Vasica, Alstonia scholaris, Andrographis paniculata, Cæsalpinia Bondu-

cella, Calotropis procera, Embelia Ribes, Ipomœa hederacea, Picrorhiza Kurroa and Podophyllm Emodi. A large supply of aconite roots from Sikkim has been supplied to Professor Dunstan to enable him to continue his researches in the aconite alkaloids, and the subject will continue to receive attention during 1905-1906.

Samples of cutch and catechu are under investigation by the Curator of the Industrial Section.

The enquiries into the forms of juar and of yams (Dioscorea) which have nearly reached completion will, it is hoped, be finished, and the study, from the economic point of view, of other field and garden crops for which materials are accumulating will be prosecuted. Assistance in this direction has been promised from many parts of India, including the province of Mysore through its Agricultural Chemist. An extensive list of foods used in India in times of famine and of scarcity is about ready for publication.

A large and representative collection of pottery clays has been brought together and despatched to the Imperial Institute for chemical and technical examination: on receipt of the reports of experts steps will be taken to apply the results for economic and industrial purposes through this Department.

8. Indian Museum, Natural History Section.

The two undertakings that will chiefly engage the attention, in addition to the ordinary routine, of this Department during the year will be—

(1) continuation of investigation upon the marine fauna in collaboration with the Marine Survey Department;

(2) continuation of investigation upon the insect fauna in co-operation with the Government Entomologist and with certain volunteers in Assam.

9. Civil Veterinary Department.

I.—(*a*) **Rinderpest.**—Further experiments with a view to raise the potency of the anti-rinderpest serum, to improve the methods of preparing, collecting and bottling. Apparatus for sterile decanting, for

defibrinating the blood, and for evaporating the serum to reduce its bulk, will be tested.

The serum will also be prepared in dry form and the utility of this method will be tried.

(*b*) Rinderpest in camels; enquiry will be continued.

II.—(*a*) **Piroplasmosis,** (*b*) **Trypanosomasis,** (*c*) **Malignant Oedema.**—These three diseases have been observed at the Laboratory appearing as secondary diseases to Rinderpest in cattle. These diseases will be further investigated as to their prevalence, the course they run, and their effect as a disease secondary to Rinderpest.

III.—Surra.—Work will be carried out on the following lines :—

(1) to attempt a prophylactic or curative serum;
(2) to attenuate the Trypanosoma by means of cultures;
(3) to attenuate the Trypanosoma by passing it through the body of animals other than equines;
(4) Surra in camels has now been under observation for several years, and a separate report on the subject will be forwarded to Government, when results are sufficiently advanced to permit of so doing.

IV.—Anthrax.—Further efforts will be made to raise the potency of the anti-anthrax serum, and investigation will be made with a view to discover a method of conferring a more lasting immunity.

V.—Hæmorrhagic Septicæmia.—The further elaborating of an anti-hæmorrhagic Septicæmia serum.

VI.—Charbon Symptomatique.—The working out of a protective serum.

VII.—Dourine.—Further observations will be made on the special features of this disease in India, and a report of the result of investigation published.

VIII.—Glanders.—Mallein will be prepared.

IX.—It is also proposed to prepare Tuberculine, Tetanus anti-toxin and anti-streptococci serum, as opportunity arises.

X.—A post-graduate class in Bacteriology and Pathology for the Officers of the Army and Civil Veterinary Departments will be continued.

XI.—The class for Veterinary Assistants will be continued as during previous years.

XII.—Material sent to the Laboratory for purposes of diagnosis will be reported on.

APPENDIX.

Economic Investigations conducted at the Imperial Institute.

BY

W. R. DUNSTAN, M.A., L.L.D., F.R.S.

Director of the Imperial Institute.

The Scientific and Technical Department of the Imperial Institute is in receipt of a grant, the present amount of which is £200 per annum, for the purpose of conducting for the various departments of the Government of India such scientific and technical investigations of economic importance as are best pursued in London, either on account of their special character and complexity or on account of the desirability of the results being communicated to manufacturers and commercial experts with a view to technical trials and commercial opinions and valuations being obtained. The Director of the Imperial Institute is a member of the Committee appointed by the Royal Society to advise the Government of India on its scientific and economic work. The channel of communication with the Imperial Institute is through the Office of the Reporter on Economic Products. The following is a brief account of the more important work which has been conducted at the Imperial Institute during the year ended the 30th September 1905.

Drugs.—*Aconites.*—The investigation of the poisonous alkaloids of the Indian aconites has been continued during the year and has furnished important results relative to the use of the different species in medicine. Two new alkaloids, which have been named indaconitine and bikhaconitine, have been discovered in *Aconitum chasmanthum* and *Aconitum spicatum*, respectively, and a paper giving an account of the pharmacology of these substances was communicated recently to the Royal Society by Professors Cash and Dunstan (Proceedings of the Royal Society, 1905). Papers dealing with the chemistry of the new alkaloids will be communicated to the Chemical Society at an early date.

Solanaceous drugs.—The enquiry into the alkaloids of the Indian *Hyoscyamus muticus* has been extended to the other species of this

genus which occur in India and also to the Indian Daturas. Specimens of *Hyoscyamus niger*, *Hyoscyamus reticulatus*, *Datura Stramonium*, and *Datura fastuosa* are at present under investigation with the object of determining the amount and nature of the alkaloids which they contain and their suitability for use in medicine or as commercial sources of the alkaloids.

Opium.—The question of the purity of the opium alkaloids manufactured at Ghazipur has received further attention during the year. A report has been furnished upon one set of samples, representing a commercial consignment of morphine hydrochloride and codeine forwarded to London for sale, and another set of similar samples is under examination at present. In connection with this work the Indian Government has referred to the Imperial Institute the question of the improvement of the manufacturing processes at present employed at Ghazipur, with the object of obtaining alkaloids which will conform to the requirements of the British Pharmacopœia. This enquiry is now proceeding and samples of the waste opium used for manufacturing purposes at Ghazipur and of the mixture of crude morphine and codeine hydrochlorides have been received for use in the investigation.

Strychnos species.—In continuation of the enquiry with regard to the constituents of the various species of Indian Strychnos, samples of *Strychnos Nux-Vomica* and *Strychnos potatorum* have been received for examination.

Rubber.—A number of specimens of rubber and rubber latices have been received from India during the year for investigation in continuation of the general enquiry into these products initiated several years ago. Amongst these were two specimens of the rubber of *Ficus elastica*, one from the Charduar plantation and the other from Parlakimedi in the Madras Presidency, and it was found on examination that the material from Charduar contained an unusually large amount of resin, 19·2 per cent., whereas a much lower percentage, 7·8, was present in that from Parlakimedi. For comparison with these figures it may be noted that a sample of *Ficus elastica* rubber which was recently received at the Imperial Institute from the Federated Malay States only contained 3·9 per cent. of resin. The large percentage of resin in the Charduar sample is important, as it would affect adversely the market

value of the rubber and it would be interesting to determine whether this feature is characteristic of the product yielded by the trees in Assam or is only accidental.

The Conservator of Forests, Assam, forwarded a consignment of the bark and leaves of *Ficus elastica*, in order to determine whether there was any possibility of extracting rubber from the material, large quantities of which are obtained in the tapping operations. The results of the investigation showed that it was very improbable that the material could be utilised in the manner suggested.

Reports have also been furnished upon the quality of the products furnished by the rubber-like latices of *Ficus comosa*, *Ficus indica*, *Ecdysanthera micrantha* and *Parameria pedunculosa*, and a specimen of the latex of *Parameria glandulifera* is at present under investigation. Of these *Ecdysanthera micrantha* and *Parameria glandulifera* yield marketable rubber, whilst *Parameria pedunculosa* demands further investigation.

Fibres—*Tacca fibre.*—Two samples of this fibre were examined and submitted to commercial experts with the object of ascertaining their suitability for use as a braiding material. It was found that one of the samples was well suited to the requirements of the London market, whilst the other, although not of the usual character, might possibly meet special needs.

Vegetable flosses.—An investigation of the flosses or so-called "silk cottons" of *Cochlospermum Gossypium*, *Calotropis gigantea* and *Calotropis procera* was carried out in order to determine the quality and value of these materials. The results showed that, on the whole, the Indian flosses were inferior to Java "kapok," but that they would be readily saleable at lower rates. An account is given in the report of the various purposes for which these products are utilised.

Agave fibres.—Two samples of Agave fibre, one of which was derived from *Agave rigida*, and the other from a species, the botanical identity of which had not been completely established, were submitted to chemical examination and comparison with other specimens. It was found that these fibres, although of fair quality, were capable of considerable improvement, and a recommendation was made that greater

care should be exercised in their extraction and preparation for the market.

Furcraea gigantea.—The examination of a sample of *Furcraea gigantea* fibre from Sambalpur Jail was carried out by the usual methods, and the results were compared with those furnished by other specimens of this fibre. It was shown that this sample was somewhat inferior to the other specimens, and it was demonstrated that this was largely, if not entirely, due to defective preparation.

Girardinia heterophylla.—A small sample of the fibre of *Girardinia heterophylla* from Calcutta was submitted to examination. The result showed that this fibre possesses valuable properties and is remarkable especially for its ability to withstand the action of alkali, its richness in cellulose, and the length of its ultimate fibre (6 – 20 inches). It is highly probable that,, if this product could be prepared on a commercial scale, it might take a high position among textile fibres.

Nannorhops Ritchieana.—A sample of fibre from the leaves of a dwarf palm, *Nannorhops Ritchieana,* has been received from the Punjab, and is at present under investigation.

Aloe fibre from Madras.—Six samples of fibre, including specimens of *Agave americana, Agave rigida, Agave vivipara* and *Furcraea gigantea* have been forwarded from Madras by the Agri-Horticultural Society, and are at present under investigation. An interesting point raised in this enquiry is the influence of the elevation at which the plants are grown on the strength and other qualities of the fibre.

Tanning Materials and Dyestuffs.—A method for the preparation of tanning extracts from the barks of *Shorea robusta* and *Terminalia tomentosa,* which are at present waste products in India, has been devised and communicated to the Forests Department. This process obviates the production of the dark purple tints usually shown by leather tanned with these barks. The suggestion has been made to the Forests Department that the tanning extracts might be prepared in India by this process.

By means of the same process it has been found possible to prepare a tanning extract from Indian Kino, which yields leather similar in

character to that produced by the highly-esteemed wattle barks of Australia and Natal. It remains to be seen whether Kino can be produced cheaply enough to permit of the manufacture of tanning extracts from it.

A sample of tanning extract prepared in India from the bark of *Ceriops Candolleana* was examined and found to be of poor quality, and quite unsuitable for use for tanning purposes.

Arrangements have been made with Mr. A. G. Perkin of Leeds to examine the constituents of the Indian dyestuffs *Onosma echioides*, *Baccaurea sapida*, *Thespesia Lampas* and *Hibiscus Sabdariffa*. He has ascertained that *Thespesia Lampas* contains the well known dyestuff *Quercetin* and *Hibiscus Sabdariffa* the colouring matter *Gossypetin* identical with that present in the flowers of *Gossypium herbaceum*. *Onosma echioides* contains a very small quantity of colouring matter, and its investigation has been delayed owing to the difficulty of accumulating sufficient material for this purpose. *Baccaurea sapida* appears to contain no colouring matter.

Fodders and Foodstuffs.—Samples of the beans of *Phaseolus lunatus* and of immature plants of *Sorghum vulgare*, grown in India, have been chemically examined. The former was shown to yield small quantities of acetone and hydrocyanic acid when ground in contact with water, and therefore the beans probably contain the glucoside *phaseolunatin* obtained from the wild *P. lunatus* of Mauritius (Dunstan and Henry, Proc. Roy. Soc., 1903, 72, 285). Of the two specimens of immature *Sorghum vulgare* examined, only one yielded hydrocyanic acid in small quantity. Further specimens of younger plants have been asked for with a view to ascertaining whether the plant is richer in the glucoside *dhurrin* at earlier stages of its growth as is the case with *Sorghum vulgare* in Egypt (compare Dunstan and Henry, Phil. Trans., 1902, 1983B, 399).

Reference may also be made to the investigation of Cassava (*Manihot utilissima*) now being carried on with specially prepared material supplied from the West Indies. It has been definitely established that prussic acid does not occur free in cassava as has generally been supposed but in the form of a glucoside. Some progress has been made in determining the constitution of this glucoside.

A careful comparison of Indian and Chinese teas is being made at the request of the India Office, with a view to ascertaining whether there is any actual foundation for the belief occasionally expressed in this country that Indian teas are inferior to Chinese teas in certain respects.

Samples of coffee obtained (*a*) from unmanured plants and (*b*) from manured plants in Mysore are being examined with a view to determining the influence, if any, of manuring on the composition of the coffee berries.

Turpentine Oil and Resin.—An enquiry is in progress with regard to the composition and properties of Indian turpentine oils and resins derived from *Pinus Khasya*, *Pinus Merkusii*, *Pinus longifolia* and *Pinus excelsa*. Reports on this subject have already been issued, and the work will be continued on the receipt of further samples from India.

Minerals.—A number of samples of graphite from the Chhatisgarh District of the Central Provinces were analysed and shown to be of poor quality and small commercial value, owing to their containing much nongraphitic material.

At the request of the Geological Survey, the constituents of a large number of Indian coals have been determined. This work is supplementary to the analyses included in Professor Dunstan's Report on Indian Coals made in 1903, and completes these by the inclusion of determinations of the quantities of phosphorus present on which the value of the coal for metallurgical purposes chiefly depends.

Analyses are now being made, also for the Geological Survey, of a large number of samples of manganese ores, laterites and pottery clays, chiefly with a view to ascertaining their technical and commercial value.

The following are the titles of the reports forwarded to India from the Imperial Institute during the year (1904-1905):—

Report on the utilisation of the Barks of *Shorea robusta* and *Terminalia tomentosa* as tanning materials.

Report on Graphite from the Chhatisgarh District of the Central Provinces of India.

Report on a sample of Tanning Extract prepared in India from the bark of *Ceriops Candolleana*.

Report on a sample of fibre of *Girardinia heterophylla* from India.

Report on a sample of *Furcræa gigantea* fibre from India.

Report on two samples of Agave fibres from India.

Report on a series of Indian Vegetable Flosses.

Memorandum on the utilisation of Indian Tacca Fibre.

Report on a sample of Rubber derived from *Ficus elastica* grown at Parlakimedi, Ganjam District, Madras.

Report on the chemical examination of immature plants of *Sorghum vulgare* (*Andropogon Sorghum* Hack) grown in India.

Report on a sample of rubber derived from *Ficus elastica* grown in the Charduar Plantation, Assam.

Report on the extraction of rubber from the bark and leaves of *Ficus elastica.*

Report on a sample of the dried fruits of *Zizyphus sativa* (*Zizyphus vulgaris* Lam.) from India.

Report on the chemical examination of the beans of *Phaseolus lunatus* grown in India.

Report on the latices of *Ecdysanthera micrantha* and *Parameria pedunculosa* from Burma.

Report on the latices of *Ficus comosa* and *Ficus indica* from India.

Report on the utilization of kino as a tanning material.

At the close of the year the following investigations were in progress :—

Leaves of *Baccaurea sapida*, flowers of *Thespesia Lampas*, roots of *Onosma echioides*, flowers of *Hibiscus Sabdariffa*, Indian Aconites, Alkaloids manufactured at Ghazipur, Manufacture of Opium alkaloids from waste Opium, *Hyoscyamus niger*, *Hyoscyamus reticulatus*, *Datura Stramonium*, *Datura fastuosa*, Latex of *Parameria glandulifera*, Fibres of *Nannorhops Ritchieana*, *Agaves* and *Furcraea gigantea*, Comparison of Indian and Chinese teas, Indian turpentine, Manganese ores, laterites and pottery clays.

Summaries of the more important of the Reports included in the foregoing list have been published during the year in the "Bulletin of the Imperial Institute," which is now issued quarterly in a new form.

During the year the following articles prepared by the Staff of the Scientific and Technical Department of the Imperial Institute, and relating especially to Indian natural products, have been published in the "Bulletin of the Imperial Institute:"—

Sisal Hemp in India	Volume ii, page 260.
Mining and preparation of mica for commercial purposes.	Volume ii, page 278.
Manufacture of coke in India . .	Volume ii, page 291.
Production of Manganese ores in India .	Volume iii, page 81.
The supply of precious stones . .	Volume iii, page 86.

The "Bulletin" circulates in the Colonies and in Great Britain, and contains special articles on subjects of economic importance in addition to reports of the investigations conducted at the Imperial Institute. Its columns are open to articles on similar subjects from those connected with Scientific Departments in India and the Colonies, and the Director will welcome any contributions from India.

C. I. C. P. O.—No. 3519 S. B.S. A.—10-4-1906.—630.—R. H. S.

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Departmental Publications.

I.—Department of Economic Products.

(1) The Agricultural Ledger—a series of papers on Economic Products issued as ready and priced according to the number of pages.
(2) Commercial Circulars printed for circulation but not on sale.
(3) Annual Report of the Industrial Section, Indian Museum.

II.—Meteorological Department.

Government of India Office.

(1) The India Daily Weather Report and Chart.
(2) The Weekly rainfall summary.
(3) The Monthly Weather Review.
(4) The Annual Summary.
(5) The rainfall of India.
(6) Indian Meteorological Memoirs.

Bengal Office.

(1) Bengal Daily Weather Report and Chart.
(2) Monthly rainfall tables and summaries of the chief features of the weather of the month over Bengal.

Bombay Office.

(1) Bombay Daily Weather Report and Chart.
(2) Monthly abstracts of the Bombay observations (Bombay Gazette).

Madras Office.

(1) Madras Daily Weather Report and Chart.
(2) Monthly rainfall tables (Madras Gazette).

Allahabad Office.

(1) Monthly Weather Summaries (United Provinces Gazette).
(2) Annual Summary.
(3) Monthly rainfall tables (United Provinces Gazette).

Lahore (Simla) Office.

(1) Monthly Summary } of Punjab weather.
(2) Annual Summary }

III.—Geological Survey.

The publications of the Department include—

Palæontologia Indica, arranged in series, and sold in parts which are priced at 4 annas (6 pence) per plate.

Memoirs, Vols. I—XXXVI, including the larger papers on geological subjects.

Records, Vols. I—XXXII, including the shorter papers and annual Reports from 1868 to 1904, sold in parts, price one rupee each.

Manuals, Guides, and Maps.

A complete list of the contents of these publications can be obtained by application to the Registrar, Geological Survey of India, 27, Chowringhee Road, Calcutta. Indexes to the Genera and Species described in the Palæontologia Indica up to 1891, to the Memoirs, Vols. I—XX, and to the Records, Vols. I—XXX, have been printed for sale.

IV.—Survey of India.

(1) Annual General Report.
(2) Professional Papers.

V.—Botanical Survey and Royal Botanic Garden, Calcutta.

(1) Annual Report of the Botanical Survey of India.
(2) Records of the Botanical Survey, Vols. I—III, No. 2, and Vol. IV, Nos. 1—3.
(3) Annual Report of the Royal Botanic Garden, Calcutta.
(4) Annals of the Royal Botanic Garden, Calcutta, Vols. I—X.

VI.—Department of Agriculture.

(1) *Annual Report.*—An account of the year's work of the Imperial Department, including the separate reports of the scientific officers of each branch (Agricultural Chemistry, Botany, Mycology, Entomology and the like).

(2) *The Agricultural Journal of India.*—A quarterly journal containing articles on agricultural matters intended for the educated agriculturist and the general reader interested in Agriculture.

(3) *Scientific Memoirs of the Department of Agriculture.*—An occasional publication for papers of a scientific or technical nature divided into series such as Chemical, Botanical, Entomological and the like.

(4) *Bulletins.*—An occasional publication containing information on agricultural matters of a temporary nature.

(5) *Leaflets.*—Short notes of practical instruction in agricultural matters, dealing mainly with entomological subjects.

VII.—Forest Department.

(1) *Review of Forest Administration in British India* by the Inspector General of Forests, (issued annually).

(2) *Annual Progress Report of Forest Administration in each Province.* Issued by the Local Governments annually.

(3) *The Indian Forester.*—A monthly journal of Forestry, Agriculture, Shikar and Travel. This is a Departmental Journal published monthly.

(4) Bulletins are published from time to time.

VIII.—Zoological Department.

(1) Annual Report.

(2) Monographs, appearing at irregular intervals.

IX.—Civil Veterinary Department.

(1) Annual Report.

ANNUAL REPORT

OF THE

BOARD OF SCIENTIFIC ADVICE

FOR INDIA

FOR THE YEAR

1905-06.

CALCUTTA:
GOVERNMENT CENTRAL PRESS.
1907.

Agents for the sale of Books published by the Superintendent of Government Printing, India, Calcutta.

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PREFACE.

THE Board of Scientific Advice for India was constituted in 1902, and consisted originally of the heads of the Meteorological, Geological, Botanical, Forest, Survey, Agricultural, and Veterinary Departments; but the Government of India intimated their intention to invite from time to time to serve upon it other scientific officers in the service of the Imperial and Provincial Governments, whose special attainments might render their assistance desirable. The Board was declared to be a central authority for the co-ordination of official scientific enquiry, its object being to ensure that the work of research is distributed to the best advantage, that each investigator confines his researches to the subject with which he is most capable of dealing, and that energy is not dissipated by the useless duplication of enquiries or misdirected by a lack of inter-departmental co-operation. It was also hoped that while the claims of abstract science would continue to be recognized in the work of the scientific departments, the Board's advice would aid the Government of India in prosecuting practical research into those questions of economic or applied science, on the solution of which the progressive prosperity of the country, especially as regards its agricultural and industrial development, so largely depends.

The Board advises generally upon the operations of the Departments, with due attention to the economic side of their work, and serves as a reference on all matters connected with the organization of scientific enquiry in India. It annually discusses the proposals of each departmental head in regard to the programme of investigation in his department; and in cases where inter-departmental co-operation is necessary, it advises as to the lines on which mutual assistance should be given and the department to which the enquiry should primarily appertain. It submits annually to the Government a general programme of research, embodying the proposals of departmental heads in so far as its subjects are to be exclusively dealt with in one department, and its own proposals in cases where two or more departments are to co-operate,

and at the end of the year it presents a brief review of the results obtained during the year in all lines of scientific investigation controlled by its members. Its reports and programmes are communicated through the Secretary of State to the Royal Society, who have appointed an Advisory Committee to consider them, and who from time to time furnish the Board and the Government of India with valuable suggestions and advice.

The present members of the Board of Scientific Advice are:

Name.	Appointment.
Mr. J. WILSON, M.A., C.S.I., I.C.S.	Secretary to the Government of India in the Department of Revenue and Agriculture. *Ex-officio* President.
Colonel F. B. LONGE, R.E.	Surveyor-General of India.
Dr. GILBERT T. WALKER, M.A., Sc.D., F.R.S.	Director-General of Observatories.
Mr. T. H. HOLLAND, F.G.S., F.R.S., A.R.C.S.	Director, Geological Survey of India.
Captain A. T. GAGE, I.M.S., M.A., B.Sc., M.B, F.L.S.	Director, Botanical Survey of India.
Dr. N. ANNANDALE, B.A., Sc.D., Officiating.	Superintendent, Natural History Section, Indian Museum.
Mr. S. EARDLEY-WILMOT	Inspector-General of Forests.
Mr. F. G. SLY, I.C.S., Officiating.	Inspector-General of Agriculture.
Colonel J. W. A. MORGAN, M.R.C.V.S.	Inspector-General, Civil Veterinary Department.
Mr. I. H. BURKILL, M.A., F.L.S.	Reporter on Economic Products to the Government of India.
Lt.-Col. S. G. BURRARD, R.E., F.R.S.	Superintendent, Trigonometrical Surveys.

List of Sub-Committees.

Sub-Committee A.—(*Meteorology, Terrestrial Magnetism, and cognate subjects*).

1. The Surveyor-General of India (Chairman) ;
2. The Director-General of Observatories ;
3. The Director, Geological Survey of India.

Sub-Committee B.—(*Agricultural Products*).

1. The Director, Botanical Survey of India (Chairman) ;
2. The Superintendent, Industrial Section, Indian Museum ;
3. The Inspector-General of Agriculture.

Sub-Committee C.—(*Soils and Manures*).

1. The Inspector-General of Agriculture (Chairman) ;
2. The Director, Geological Survey of India ;
3. The Inspector-General of Forests.

Sub-Committee D.—(*Forest Products*).

1. The Inspector-General of Forests (Chairman) ;
2. The Superintendent, Industrial Section, Indian Museum ;
3. The Director, Botanical Survey of India.

Sub-Committee E.—(*Veterinary subjects*).

1. The Inspector-General, Civil Veterinary Department (Chairman) ;
2. The Inspector-General of Agriculture ;
3. The Superintendent, Natural History Section, Indian Museum.

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ANNUAL REPORT

OF THE

BOARD OF SCIENTIFIC ADVICE FOR INDIA

FOR

1905-06.

SUMMARY OF PROCEEDINGS.

8th Meeting held at Simla on the 5th May 1906.

AFTER disposal of formal business, the Board considered a memorandum by Lieutenant-Colonel Prain on the subject of the cultivation in India of flax for fibre and on suggested improvements in the methods of retting. They were given to understand that experiments in the cultivation of flax for fibre on a commercial scale had been undertaken by a company in Behar, and that arrangements had been made to obtain through the Secretary of State a quantity of the best Russian and Belgian seed for distribution to planters interested in flax growing and to selected Government farms. The question of the further encouragement to be given to the flax-fibre industry being then under discussion with the Government of Bengal, the Board resolved for the present to reserve an expression of their opinion on Colonel Prain's Memorandum.

On the report of their Sub-Committee on the botanical investigation of Indian cottons, the Board expressed their appreciation of the

valuable work done by Mr. G. A. Gammie, Economic Botanist to the Government of Bombay, who had made a special study of Indian cottons for several years, and recommended that he should be invited to continue his investigation, with the help of the Reporter on Economic Products to the Government of India and the Director of the Botanical Survey, with a view to ultimately preparing a revised edition of his work on 'Indian Cottons.'

The Board supported the recommendations made by their Sub-Committee on the use of mineral fertilizers in India, to the effect that the various Agricultural Departments should undertake experiments to test the results of the use of the principal mineral fertilizers, and that particular attention should be given to the trial of ammonium sulphate in sugarcane cultivation, as that chemical was likely soon to become readily available in India and was largely used as a fertilizer for sugarcane in other countries in the East.

The Board took into consideration a report by a Sub-Committee on the work of the Civil Veterinary Department, more especially in connection with the study of particular animal diseases, and resolved to adopt the report and submit it to Government for transmission to the Royal Society.

The programmes of work of the various scientific departments for 1906-07 were then considered and approved by the Board with minor alterations.

9th Meeting held at Calcutta on 17th December 1906.

The Board discussed a letter from the Director of the Geological Survey giving a short preliminary account of the progress made in the examination of certain of the Himalayan glaciers, and resolved to forward a copy of the letter to Government and to suggest that a revised notice for the examination of glaciers should be prepared by the Director of the Geological Survey to accompany the reports to be distributed for the information of travellers.

Correspondence regarding the working of the septic tank installation at Muzaffarpur, and regarding the examination of the Hooghly water and on the use of chloride of lime in sterilizing septic tank effluents, was read and recorded.

Correspondence conveying remarks of the Advisory Committee of the Royal Society on the work of the Meteorological Department,

particularly with regard to the desirability of early publication of monthly maps of the Indian Ocean, was considered. The Board were of opinion, in view of the facts mentioned in a letter to Government by the Director-General of Observatories, that some delay must occur before monthly maps of the Indian Ocean could be prepared. The Director-General of Observatories, however, was to be asked to submit a further report in the course of next year.

The Board understood, from correspondence forwarded by the Inspector-General of Agriculture, that with regard to the investigation of glucosides Dr. Leather, the Imperial Agricultural Chemist, was to examine the conditions under which the glucosides were formed, while their isolation and examination were to be taken up by Professor Dunstan, the Director of the Imperial Institute.

The Annual Report of the Board for 1905-06 was considered and after emendation recommended for acceptance by Government. In view of the information given in the zoological sections of the Report, the Board were of opinion that the facilities for zoological work in India should be increased, and resolved to draw the attention of Government to the fact.

The question of the revision of the Dictionary of the Economic Products of India was then discussed, and the Board were of opinion that no general revision of the Dictionary should be undertaken for several years, in view more especially of the fact that scientific enquiry into agricultural and veterinary subjects has only recently been organised on an adequate scale. It was suggested to the Board that a revised edition containing only those minor articles not included in the abridgment now about to issue might be undertaken at once. This suggestion was referred to a sub-committee with instructions to report direct to Government at an early date.

Further correspondence on the cultivation of flax for fibre and regarding the botanical survey of India was read and recorded.

A proposal by the Superintendent of the Natural History Section of the Indian Museum for systematic investigation of the small mammals likely to act as transmitters of Plague was considered, and the Board resolved that a copy of the letter embodying the proposal should be forwarded to Government with the remark that the Board agreed generally with the suggestions made and recommended them to the consideration of Government.

ANNUAL REPORT FOR 1905-06.

ECONOMIC AND INDUSTRIAL CHEMISTRY.

BY

J. W. LEATHER, PH.D., F.I.C., F.C.S.,
Imperial Agricultural Chemist,

AND

D. HOOPER, F.I.C., F.C.S., F.L.S.,
Curator, Indian Museum.

As the instructions given regarding the period to be covered by this review laid it down that it was to be the period covered by the Departmental Reports of the officers writing, this section is made to cover the year from April 1st, 1905, to March 31st, 1906, in regard to information of chief interest to the offices of the Reporter on Economic Products and to the Industrial Section of the Indian Museum, and in the main to keep to that period in regard to information of chief interest to the Agricultural Department. It embodies all work reported as done in India by departments closing their annual report at the end of March 1906 and all work on Indian material that has been put before the public between April 1st, 1905, and March 31st, 1906. In dealing with the numerous chemical investigations it has been considered convenient to adhere to the arrangement of last year, *viz.*, the method of classification of products in the Economic Court of the Industrial Section of the Indian Museum.

Caoutchouc.—Much interest has been shown in the valuation of India-rubbers obtained from India. Some of these are of good quality, but the majority of samples came from inferior sources. The chief source of commercial rubber in India is the *Ficus elastica* of Assam, where there are plantations at Charduar, and of which the outturn of rubber sometimes amounts to 2,000 lbs. per annum. The rubber is not the best in the market as it yields from 80—86 per cent. of pure caoutchouc, Para rubber affording over 90 per cent. During the year the rubber from trees growing experimentally at Ganjam, Madras, Poona, and Burma were examined The composition varied within certain limits and on the whole resembled the Assam product; the Ganjam rubber indicated 88·6 per cent. purity, the Poona sample 82·5 per cent., and that of Burma 82·7. A specimen from Kurseong, Bengal, examined in 1903 afforded 84·3 per cent. of pure caoutchouc.

The value of the rubber in the market depends not only on the proportion of caoutchouc but also on the low amount of the impure resinous principles in it; and they range from 4 to 19 per cent.; the determination of the cause of this variability is worthy of investigation, and experiments might be made to show whether it is due to the habit of the tree, the season of collecting latex, or the nature of the soil and climate of the district.

It is a remarkable fact that, apart from *Ficus elastica*, the various wild and cultivated Indian species of Ficus, although yielding an adhesive latex, afford no commercial rubber. During the year several of these exudations have been tested. At the Indian Museum *F. Benjamina*, *F. mysorensis*, *F. tomentosa*, *F. bengalensis*, and *F. religiosa* were examined; at the Imperial Institute *F. comosa* and *F. indica*; and by an independent analyst *F. infectoria*. In each case the samples were loaded with resins, and the highest yield was 30 per cent. of an inferior caoutchouc.

Resins.—J. C. Umney contributed to the Pharmaceutical Society (*Pharm. Journ.*, 1905, 75, 653-654) a paper on 'The Commercial Grades of Lac and their Valuation.' The author reviewed the forms of lac met with in London commerce and determined their solubility, acid and ester numbers and iodine value. He incidentally described the process for the qualitative detection of resin and the chemical methods in vogue for bleaching shellac. A. Etard and E. Waller (*Comptes rend.*, 1905, 140, 1603-1606) have conducted researches in the destructive distillation of lac and embody their results in a paper entitled 'Pyrogenetic Decomposition of Lac Resin.' The authors conclude their investigation by stating that the results indicate that lac resin is possibly composed of a series of unstable oleates of polyterpenes.

Oils.—Following on the work of investigating the chaulmugra seeds of commerce which was reported last year, F. B. Power and M. Barrowcliff have studied the 'Constituents of the seeds of Gynocardia odorata' (*Journ. Chem. Soc.*, 1905, lxxxvi, 896-899). This oil is quite distinct from that of the chaulmugra seed, for whereas chaulmugra oil at the ordinary temperature is a solid (m. p. 20°—23°), the oil of the Gynocardia seeds is a liquid. Furthermore, chaulmugra oil is optically active and consists of the glyceryl ester of members of the chaulmugric acid series, whereas the oil from Gynocardia seeds

is optically inactive and contains neither chaulmugric acid nor its homologues. The following organic acids have been separated from it: linoleic acids, or isomerides of the same series, constituting the largest proportion of the oil; palmitic acid in considerable amount; linolenic and isolinolenic acids; and oleic acid in relatively small amount. M. Greshoff (*Chem. Centr.*, 1905, i, 683) confirms the presence of prussic acid in these seeds (see last report, p. 19) and obtained 0·92 per cent. in the expressed oil.

Messrs. Power and Barrowcliff have also examined the seeds of two other plants used as substitutes of the true chaulmugra (*Journ. Chem. Soc.*, 1905, lxxxvii, 884-895). These are the seeds of *Hydnocarpus Wightiana* and *H. anthelmintica*. The first named tree is indigenous to the Western Peninsula of India, and the oil has been used in Bombay for leprosy. The oil contains chaulmugric acid and a lower homologue of the same series. This new acid has the formula C_{16} $H_{28}O_2$, and melts at 60°, and it is designated hydnocarpic acid. The oil of the seeds of *H. anthelmintica*, a Siamese drug, contains chaulmugric and hydnocarpic acids and affords indications of the presence of a cyanogenetic glucoside.

Til seed (*Sesamum indicum*) is largely grown in India, and it is interesting to notice that it has been critically compared with the seed grown in other countries. H. Sprinkmeyer and H. Wagner (*Zeit. Untersuch. Natur. u. Genüssm.*, 1905, 10, 347-353) have completed some work on the 'Characteristics of Sesame Oils of different origin.' The seeds were procured from India, Levant, and Africa, and the yield of oil was from 50 to 54 per cent. No material differences were observed in the chemical and physical values of the Indian and Levant oils, but that from Africa had a considerably higher iodine value, optical rotation, and refractometer reading.

The composition of Nux-vomica fat has been the subject of two investigations by F. Harvey and J. M. Wilkie (*Journ. Soc. Chem. Industry*, 1905, xxiv, 718-719) and A. Schroeder (*Arch. Pharm.*, 1905, 243, 628-640). The latter author shows the presence in the oil of arachidic and palmitic acids, a phytosterol, a substance resembling colophony, and strychnine and brucine.

The Chil pine (*Pinus longifolia*) is indigenous to the Lower Himalayas, and the turpentine oil and resin are obtained on a commercial

scale from the trees and supplied by the Forest Department at Dehra Dun, and Naini Tal in the United Provinces, and at Nurpur in the Punjab. The turpentine has been receiving attention in Europe and has been examined by Frank Rabak (*Chem. Centr.*, 1905, ii, 896-897). The essential oil separated by steam amounted to 18·5 per cent., and probably contains *l*-pinene and *d*-limonene. The resin, left after distillation, had an acid number of 142 and saponification number of 155. Crystals of a resin acid melting at 138°—140° separated from the solution of the crude resin in glacial acetic acid.

An important paper has been published by H. Walbaum and O. Huthig (*Journ. für. praktische. Chem.*, 71, 459-473) on Ginger-grass oil (*Andropogon Schœnanthus*), prepared in India and exported from Bombay. The constituents isolated and examined by these chemists are : *d-a*-phellandrene, *d*-limonene, dipentene, aldehyde $C_{10}H_{16}O$, *i*-carvon, geraniol and dihydrocumin alcohol. A sample of the grass distilled in Java gave a yield of 0·3 per cent. of oil. This oil was found by Dr. de Jong to have a specific rotation of 1°2', specific gravity 0·879, and a geraniol content of 88 per cent. This oil has received a satisfactory report in Europe (*Teysmannia*, xvi, 259). There are certain points in the botany and chemistry of the grass oils which need elucidation, and the Reporter on Economic Products is engaged in collecting authentic samples of the grasses and having the oils examined by experts.

Dyes and Tans.—Continuing his researches in the vegetable colouring matters, A. G. Perkin has contributed an important paper to the Chemical Society, London, on 'The Constituents of Gambier and Acacia Catechu' (*Journ. Chem. Soc.*, 1905, lxxxvii, 398-404). The author draws attention to the alleged identity of the catechin of gambier and that of the wood of *Acacia Catechu*, and refers to the work of Clauser and of Kostanecki and Tambor who supported this view. Perkin has carefully examined these principles, and concludes that while the formulæ of catechin and acatechin are identical, the difference in the melting points of their derivatives shows them to be distinct substances. The two catechins are, however, so similar in their behaviour with ordinary reagents that no doubt can be entertained as to their intimate relationship.

In a paper on Cyanomaclurin by the same author (*Journ. Chem. Soc.*, 1905, lxxxvii, 715-722) it is shown that this constituent of

the Indian dye stuff, Jackwood (*Artocarpus integrifolia*), is extremely closely allied in its properties to the catechins of cutch.

Dr. M. Greshoff of the Colonial Museum, Haarlem, published an article on the 'Determination of the value of Gambier or Yellow Catechu' (*Chem. Centr.*, 1905, ii, 993). The analytical details are given for estimating the solubility in water, the tannin, catechin, and moisture, and analyses of genuine samples of the drug are tabulated.

During the year the Society of Arts, London, has issued a report of the Committee on Leather for Book-binding. The report deals with the suitability or otherwise of various vegetable tanning materials. With regard to Turwar bark (*Cassia auriculata*) it gives a pale yellowish tannage, but an unfailing characteristic of the colour is the reddening which takes place in the leather when exposed to sunlight. For this reason catechol tannages, such as the East Indian cassia, is unsuitable for book-binding and upholstery, however valuable it may be for general purposes.

D. Hooper (in *Indian Forester*, 1905, xxxi, 717) draws attention to the Croton oil tree (*Croton Tiglium*) of South India, as a new source of the astringent gum known as kino.

Among a number of plant products supplied by the Reporter on Economic Products to the Government of India to Professor Schaer of Strassburg are the bark and fruits of *Ægiceras majus*, found in the Sunderbuns. One of Professor Schaer's pupils, H. Weiss, has chemically examined these products and has given his results in a paper entitled 'Ægiceras majus with especial reference to saponin' (*Arch. Pharm.*, 1906, 244, 221-233). The bark contains 1 per cent. of saponin and a crystalline substance $C_{22}H_{24}O_2$. The latter melted at 83—84°. Thesaponin when hydrolised with 2 per cent. of sulphuric acid yields 20·4 per cent. sapogenin and 13·0 per cent. of pentoses and galactose. The husks do not contain saponin. From the kernels, on the contrary, a saponin was isolated chemically identical with that found in the bark, but physiologically ten times more powerful in its action on the red blood corpuscles.

Medicinal Substances.—Indaconitine: the alkaloid of Aconitum chasmanthum, by W. R. Dunstan and A. E. Andrews (*Journ. Chem. Soc.*, 1905, lxxxvii, 1620-1635). The alkaloid obtained from this plant and described in the paper proves to be exceptionally interesting since it represents a compound intermediate between the Aconitine of

the European *A. Napellus* and the pseudaconitine of the Indian *A. ferox* or *deinorrhiza* Stapf.

Bikhaconitine, the alkaloid of *Aconitum spicatum*, by W. R. Dunstan and A. E. Andrews (*Journ. Chem. Soc.*, 1905, lxxxvii, 1636-1649). Whilst this alkaloid differs in properties from other known aconitines it is closely related to pseudaconitine both in its chemical properties and physiological action.

The aconitine group of alkaloids, by W. R. Dunstan and T. A. Henry (*Journ. Chem. Soc.*, 1905, lxxxvii, 1650-1656). A review of the chemistry of the aconite alkaloids.

The pharmacology of Indaconitine and Bikhaconitine, by J. T. Cash and W. R. Dunstan (*Proc. Roy. Soc. B.*, 1905, 76, 468-490). The physiological action of these alkaloids shows a qualitative agreement with aconitine, japaconitine, and pseudaconitine. Aconitine and indaconitine are about equally poisonous, japaconitine is rather more active than these but not quite as toxic as bikhaconitine, whilst pseudaconitine is the most active of the series.

Three papers on Solanaceous alkaloids have appeared in German publications and should be referred to.

Alkaloids of some Solanaceae which induce mydriasis, by E. Schmidt (*Arch Pharm.*, 1905, 303-309) The paper deals with a comparative study of different plants of this order. *Datura Metel* contains scopolamine (hyoscine). *D. arborea* contains scopolamine in all its parts accompanied by a small quantity of hyoscyamine. *Atropa Belladonna* yields chiefly hyoscyamine.

Alkaloids from certain species of Datura which induce mydriasis, by Adolf Kircher (*Arch. Pharm.*, 1905, 243, 309-328). The author confirms the results of E. Schmidt with regard to *D. Metel* and *D. arborea*, and finds the alkaloid of *D. Stramonium* to be mainly hyoscyamine.

Quantitative investigation of the distribution of the alkaloids in the organs of *D. Stramonium*, by Julius Feldhaus (*Arch. Pharm.*, 1905, 243, 328-348). The paper is of interest from the standpoint of physiological botany. The percentage of alkaloid varied from 1·39 in the ribs of the leaves to 0·082 in the ripe pericarp, ·90 occurred in the main stem and 0·10 in the main root. The percentage in the seeds varied from 0·21 to 0·48 according to locality.

The following medicinal substances were examined by D. Hooper

in the Indian Museum Laboratory and were referred to in the last Annual Report of the Industrial Section of the Museum.

Ipomœa hederacea, Kala dana.—The seeds are at present under investigation by the Indigenous Drugs Committee. They yield 8 per cent. of resin, resembling the convolvulin of jalap tubers, and 14 per cent. of fat. The seeds are comparatively rich in albuminous substance, and the presence of a nauseous tasting fat is a disadvantage in a medicine administered internally, and interferes with the separation of the resinous active principle.

Mallotus philippinensis, Kamala.—This article consisting of the glands of the fruit is used as a dye stuff and as a medicine. It is subject to adulteration, and its reputation has fallen within recent years partly on this account and partly because of the influx of modern aniline dyes into India. Of twenty-two samples exhibited in the Indian Museum, only seven samples afforded ess than 10 per cent. of ash

Picrasma javanica.—This large tree is common in the Ataran Forest Division, Tenasserim, where it is called by the Karens "Napaw-ow." The bark is exceedingly bitter and is used by the Karens as a febrifuge instead of quinine. The bark contains a bitter principle allied to quassiin, and has an advantage in containing no tannin. There is no alkaloidal principle such as quinine in the bark.

Rhazya stricta.—The leaves of this small shrub growing in Baluchistan, Afghanistan, and Arabia are used in medicine in Northern India, especially in the Punjab and Sind. The plant is called Ishwarg, and the leaves are reputed to be a bitter tonic for fevers and general debility, and they have been reported as poisonous. The leaves contain a large quantity of alkaloids, one of which is volatile and has the odour of coniine, the alkaloid of hemlock. The non-volatile alkaloid resembles in some particulars one of the bases of Aspidiosperma; it dissolves in sulphuric acid with a red colour, changing to purple, and contains 8·01 per cent. of nitrogen.

Foods.—In the Indian Museum an examination has been made of the root of *Costus speciosus*, a plant common in moist, shady places throughout India. The root is used as a food stuff among the poorer classes. (See Agricultural Ledger, No. 2 of 1906.)

Ormosia tavoyana.—The seeds of Thitmyo or Thakhi-baw are used as a food substance for cattle in Burma. They contain water 14·25,

fat 2·25, albuminoids 11·42, carbohydrates 61·88, fibre 7·10, ash 3·10. The seeds are white, palatable, and fairly nutritious.

Sterculia villosa.—An instance of the innutritious value of some famine foods is shown in the fibrous root of this Sterculia from the United Provinces. It contains water 9·85, fat 0·85, albuminoids 3·93, carbohydrates 51·97, fibre 19·30, and ash 14·10 per cent. The root becomes mucilaginous when soaked in water, but its nitrogen content is very low, and the fibre and insoluble ash are excessive.

Glyceria fluitans.—C. Hartwick and G. Hakanson (*Zeit. Natur. Genüssm.*, 1905, 473-478) have examined the grain of the manna grass of the Punjab. The cereal affords water 13·54, albuminoids 9·69, fat 0·43, starch and sugar 75·06, fibre 0·21, and ash 0·61 per cent.

Manna.—The gummy exudation of the *Schrebera swietenioides* has been examined by D. Hooper and found to be a manna, since the crystalline constituent has the properties of mannite.

Tea.—Dr. H. H. Mann has continued his investigations into the fermentation of the tea leaf, and has described in some measure the changes which occur in the quantity of the active enzyme from the time the leaf is plucked until it is ready for manufacture. In the latest report on 'The Fermentation of Tea, Part I, 1906,' the author reviews the constituents of tea, the changes occurring during fermentation, the loss of soluble constituents during fermentation, the effect of heavy rolling, and the effects of increasing the time and raising the temperature during the process. The practical summary of the investigation indicates that every effort should be made to attain three conditions in tea fermentation:—

(1) The maintenance of a temperature of 82° F. or below.
(2) The production of a saturated atmosphere.
(3) The provision of conditions as free as possible from injurious microbes, in other words, of extreme cleanliness.

Cyanogenetic glucosides.—A good deal of information on the subject of cyanogenetic glucosides has been published during the year, and the accumulated evidence shows how widely these substances occur in the vegetable kingdom. Dr. Greshoff in a paper read before the last meeting of the British Association gave a list of no fewer than seventy-five orders and sub-orders of plants from which hydrocyaric acid or prussic acid has been obtained. Moreover, so many

fatal cases of poisoning have occurred in India, Great Britain, and the Continent, due to the consumption of seeds from India and the East, that the subject is an important one in this country and requires more than a cursory reference. Whilst the isolation and examination of those glucosides is of the first importance, we still know but little regarding the conditions under which they are formed in excessive quantity, and it is clear that this is in no sense a secondary question.

The general idea has been that much depends on variety. Whilst there is perhaps no evidence that could be said to negative such a view, it is clear that the same variety may contain at different times very different quantities of its characteristic glucoside. For instance, during the current year a number of varieties of jowar (*Anaropogon Sorghum*) have been grown at the Agricultural Research Institute, Pusa, under very varying conditions as regards both manure and water-supply, and in *no* case was the glucoside dhurrin formed in more than the most minute quantities even in the immature plant.

Another case is that of the Lima or Duffin bean (*Phaseolus lunatus*), an account of which has been written by Professor Dunstan and published in the Agricultural Ledger, No. 2 of 1905. It is necessary to emphasise the recommendation contained in this paper to cultivate the white variety of bean instead of the dark or coloured varieties which are often poisonous. Since the publication of last year's report other instances of poisoning have occurred, to which reference should be given. A. Robertson and A. J. Wynne (*Zeit. anal. Chem.*, 1905, 44, 735-741) report the death of four persons who had made a meal of Lima beans. The cause of death was traced to prussic acid, of which 0·2 per cent. was found in the dark-coloured seeds. Again, in Great Britain no fewer than eight cases of very serious poisoning, involving the loss of numerous cattle, have been traced to the eating of 'Java beans,' identified as the seeds of *Phaseolus lunatus*. In London, Tatlock and Thomson have examined a number of specimens of these beans obtained from different sources (*Analyst*, xxxi, 1906, 250) and found either no prussic acid or only small quantities in most; but the 'Java' beans formed an exception, and, like those which M. Guignard analysed, they yielded large amounts of prussic acid. 'Burma' beans yielded only moderate quantities.

Another very important question is whether, provided the hydrolytic enzyme, which is apparently always present with these glucosides,

is destroyed by heat, the glucoside which would become hydrolysed by the various enzymes of the digestive organs. On this point experiments made by Professor McCall of the Glasgow Veterinary College (*Journ. Board Agric. London*, xiii, 52) yielded some positive evidence. Some of the 'Java' beans which had caused so much harm were fed to a short-horn cow, a collie dog, and a white cob. They all died, although the meal was *boiled* previous to being fed to the dog. So that in the latter case the hydrolysis must have been effected by the digestive organs. It was also noticed that some 15 to 20 minutes elapsed between the time of ingestion and appearance of toxic symptoms, the cause of this being the time required in each case for the production of the hydrocyanic acid.

The linseed plant also yields a cyanogenetic glucoside and should be used with caution as a fodder. In the Banda district of the United Provinces a herd of cattle ate some linseed and 42 died of symptoms of prussic acid poisoning. The plant was in a fairly advanced state of maturity, for the seed had partly formed. It yielded 1·4 grain of prussic acid per pound of sun-dried fodder.

Experiments in the cultivation of *Phaseolus lunatus* have been made by L. Guignard (*Comptes. rend.*, 1906, 142, 545). Three specimens which had come from Java, Burma, and Madagascar were grown in Provence. The seeds had yielded, respectively, ·05 to ·10 per cent., ·006 to ·015 per cent., and ·008 to ·03 per cent. The seeds from the plants grown in Provence, however, contained either no glucoside or only minute quantities. Further experiments will have to be made in India in the cultivation of these beans, of jowar, and of linseed to ascertain the conditions under which hydrocyanic acid and its glucoside is developed or suppressed in the living plant.

Alcoholic Liquors.—During the year a report on the quality, manufacture, and excise control of alcoholic liquors in India was submitted to the Finance Department, Government of India, by Major C. H. Bedford, D.Sc., I.M.S., who had been specially deputed to conduct this investigation.

The various methods for the quantitative estimation of the by-products of alcoholic liquors were subjected to a thorough comparative examination. Of the existing processes the aniline acetate colorimetric method for furfural, the fuchsine bisulphite method for aldehydes and the Allen-Marguardt process for "fusel oil" (higher alcohols)

were found preferable. Since the publication of the report a new method for the estimation of higher alcohols has been devised by Major Bedford and he has described the process under the name "Ester-Iodine" process. It has been conclusively proved to give by far the most reliable and exact indications of any previously known method for estimating higher alcohols and to reduce the time occupied for a spirit-analysis by one-third where the Allen-Marguardt process for fusel oil had previously been in use.

In the course of the investigation the products of every Indian distillery and every type of fermented liquor obtainable in India were qualitatively analysed, over 2,000 complete spirit-analyses being required, with the general result that Indian-made liquor shows, in a large proportion of cases, an excessive proportion of furfural and of acidity. The methods of preventing the production of these high proportions of by-products were clearly pointed out. The whole subject of the technology of manufacture of Indian spirits has been passed in review and practical suggestions made for the improvement of spirit-manufacture in India.

A thorough investigation of the physiological action (by means of over 1,000 experiments on men and animals) of the various known by-products of alcoholic liquors was also carried out. The general conclusion arrived at was that, although certain of these by-products are, if taken in sufficient quantities, very poisonous, yet in the amounts ever found in potable liquors their action is inappreciable and may safely be disregarded for practical purposes.

A large amount of original work was done in connection with methods of excise control. Standard and excise tests of quality were shown to be unnecessary in view of the steps which are to be taken to remove existing defects in Indian spirits by means of improvement of manufacture and in view of the proved negligibility as regards noxious action of the relatively small amount of such impurities found in potable liquors.

Other subjects dealt with in detail were observations of alcoholic strength for excise and customs purposes, and a modified method was described by which the present heavy losses in estimating "obscuration" for customs purposes could be prevented, thus resulting in a marked gain of customs revenue to Government. The question of the accuracy and standardisation of excise hydrometers was also dealt with, certain

large losses of revenue from the use of inaccurate instruments were pointed out, and means for preventing such in future stated. A curious point which was also investigated was the *increase* of alcoholic strength in spirits on keeping under certain conditions. A considerable amount of work was done on the subject of wastage in connection with reduction of blending operations in bond, and a new simplified method was devised for the use of excise officers.

The question of improvement of alteration in spirits on maturing was also examined, and also the subject of identifying *licit from* illicit spirits by the help of a dye otherwise of negative properties, but which would respond to a very simple and distinctive excise test.

The nature of certain native yeasts (Indian and Chinese) was investigated and the subject of poisoning of native yeast (" bakhar ") and rice beers (practised with the view of increasing their potency) was also dealt with.

A number of subjects of great practical importance, such as the limits of spirit yield, from the various fermentive bases, the most suitable yeasts to employ, the investigation of fermentation failures in distilleries, evaporation, wastage, and many others were detailed for future consideration at the Central Excise Laboratory, which the Government of India have since decided is to be maintained at Kasauli.

In addition to the above, Major Bedford has also devised a new method for the denaturalisation of industrial spirits. A means for improving the process of denaturing alcohol is regarded as one of the chief methods by which traders using industrial alcohol may be assisted by Government.

Under the subject of Alcoholic Liquors reference should be made to a paper on ' The Hindu Method of Manufacturing Spirit from Rice, and its scientific explanation,' read by J. C. Ray of Cuttack before the Asiatic Society of Bengal (*Journ. Asiat. Soc. Beng.*, N. S. ii, 129-142). The native beer, pachawi, is made from rice, water, and a ferment called bakhar. Bakhar is a mixture of powdered rice, barks and roots of various plants, and contains a diastase capable of converting starch into dextrin and maltose. The rice is prepared by forming it into cakes with water and mixing it with the ferment ; after a few days it is treated with more water and allowed to undergo the process of brewing. From an examination of the wort taken at different seasons the author prepares tables giving the yield of alcohol

and volatile acids, and concludes by summarising the best conditions under which rice fermentation may be conducted in this country.

Inorganic and Mineral.—*Saltpetre or Potassium Nitrate.*—The importance of saltpetre as an agricultural fertiliser in India has necessitated an investigation into the distribution of the nitre deposits of the country and the methods of manufacture adopted in separating and refining the salt. The results of these enquiries have been embodied in a Report on the 'Manufacture and Composition of Indian Saltpetre,' by D. Hooper (*Agricultural Ledger*, No. 3 of 1905). The report explains the process of nitrification, the districts where nitre earths occur, and where the salt is manufactured. The manufacture of saltpetre is described and tables are given of the analyses of numerous samples of nitrous earth, crude and refined saltpetre, impure and purified table salt, and other by-products.

Field experiments in Europe are recorded to prove the value of calcium cyanamide to approach or equal that of sulphate of ammonia. Pot cultures made at the Imperial Agricultural Research Institute, Pusa, with both these compounds, have supported these views.

It is proposed to utilise a part of the electric energy at the Kashmir installation for the manufacture of calcium nitrate, and if this were carried into effect, the Indian monsoon would not only provide water for the canal system, but would also indirectly place a supply of fertiliser at the disposal of crops.

Drainage.—During the current year four gauges designed for the measurement of the amount and quality of the drainage water from agricultural land have been constructed at the Agricultural Research Institute by Mr. M. H. Arnott, Public Works Department, who devoted much care and trouble to them. They are similar to those at Rothamsted and Cawnpore. The soil of the area in which they are situated consists of a fairly permeable loam throughout the first four feet; this is followed by a stratum of sand about two inches thick and thereafter a bed of much stiffer soil which extends to more than thirteen feet from the surface. Two of the gauges are three feet thick and therefore only include the upper loam; the other two are six feet thick and thus include the upper loam, the thin sand stratum, and two feet of the stiff soil. Thus the nature of the soil in the two pairs is not the same, and it also differs from those at Cawnpore. The records of only one of the 3-foot Pusa gauges could be carefully kept this year, and so far

these data are similar to what has been found elsewhere, but from the behaviour of the 6-foot gauges, it is probable that future records will show these to possess some peculiarities.

One of the facts which has been demonstrated by these gauges both in England and in India is that the amount of percolation varies with the rainfall and that the amount of evaporation (plus that which is absorbed by the soil at the end of the hot weather) is nearly constant and the data at Cawnpore continue to substantiate this.

The condensed data may be expressed thus :—

	Rain during monsoon.	Percolation.	Overflow from surface.	Difference.
	inches.	inches.	inches.	inches.
1903 . .	23·5	11·5	...	12
1904 . .	43·4	25·7	4·0 (approx.)	13·7
1905 . .	17·1	3·0	...	14·1
1906 . .	32·3	18·4	...	13·9

One very striking feature of the Pusa gauge soil is illustrated by the amount of surface drainage. It was decided to provide in the Pusa gauges for the measurement of any water which flowed off the surface during heavy rain. All such gauges have a horizontal surface and a curbstone round them. These curbstones at Pusa each have three overflow pipes at 2 inches, 3 inches, and 4 inches, respectively, above the surface of the soil and these empty into small measuring tanks. As these pipes are provided with taps, either 2 inches, 3 inches, or 4 inches of water can be held up on the gauges at will. For this year all the taps were kept open so that not more than 2 inches of water could accumulate on the surface before overflowing. The only really heavy falls of rain which occurred were on August 13th when 4·9 inches were registered in 24 hours, and of this *none* overflowed, and on August 25th when 2·13 inches fell in about one hour, and on this occasion ·23 inch water was found to have overflowed from one of the gauges; none overflowed from the others. It is naturally open to discussion whether the overflow pipe at 2 inches above the ground level is too high to imitate average natural conditions; these vary within wide limits; but it is certainly surprising that this soil, already apparently fully saturated, should have absorbed 5 inches of water in 24 hours with a "head" of less than 2 inches.

The nitrate in the drainage water.—It was mentioned in the last report (p. 21) that the drainage water at Cawnpore contained large amounts of nitrate in 1904. The rainfall in 1905 was only 17·1 inches during the monsoon and the quantity of drainage was consequently only about 3 inches. The quantity of nitrate was also small. The recent rainfall has been a heavy one and the quantity of nitrate is again very large. The drainage water at Pusa has, on the other hand, contained only a very small amount of nitrate. This was fully anticipated. When in January the construction of these gauges was commenced, the soil of the same field, and situated only about six feet from the actual gauges, was examined very carefully indeed for nitrate, and the quantity was found to be about ·2 part nitrogen as nitrate per million parts of dry soil, or assuming that this soil during periods of wet weather contains about 25 per cent. of water, which is approximately what has been observed this year, it might have been anticipated that the drainage water would contain less than 1 part per 1,000,000. The waterfrom the 3-foot gauge has contained 3 parts per million. The soil of the land contiguous to the Cawnpore gauges has not been examined in this way. It is a determination which can only be carried out on the spot and with very special arrangements, but whenever this is done (and it is proposed to do it during next year) it is certain that the Cawnpore soil will be found very different in this respect from the Pusa soil. As a matter of fact, the past history of the Cawnpore field would lead one to anticipate a high proportion of nitrate in the drainage water, for it is land which was liberally manured for some years previous to the construction of the gauges ; moreover, the well water close by contains also large amounts of nitrate. But it is not so clear why the Pusa soil should be so very deficient in this constituent. It had been out of cultivation for a long time and carried only one crop of oats in 1904 before the gauges were made. It might have been anticipated therefore that an accumulation of organic matter would have been taking place and that this would now nitrify rapidly. The Pusa well waters, however, support the view that the drainage water of this land is unusually free from nitrate, for they contain only very nominal quantities. It may be mentioned in conclusion that it is not intended to treat all these four gauges in the same manner. The Rothamsted gauges have been maintained in a fallow condition, and so have the Cawnpore gauges up to the present. But the intention has been to grow crops

on two of the Cawnpore gauges and to maintain only two fallow. For the present two of the Pusa gauges will carry grass (*Cynodon dactylon*) and two will be fallow.

Edible Earths.—In the course of a special investigation into the subject of earth eating and the earth-eating habit in India, D. Hooper and H. H. Mann submitted to complete analysis thirty-three samples of edible clay. The clays were naturally silicious ; eight samples containing over 80, twelve over 70, and six over 60 per cent. of silica and sand. A sacred earth called Gopichandana was a marl with 61·35 per cent. of calcium carbonate ; only eight of the other samples exceeded one per cent. of lime. A buff-coloured shale called Multani Matti was received from Baroda, Baluchistan, and Manbhum where it is sold in the bazars for edible purposes. Laterite is the edible clay of Mysore, and halloysite that of Travancore and the Wynaad. Cimolite is baked and eaten in Bombay, and hydrated silica is used in Madras and Travancore. Palia stone of Rajputana, a stone eaten in time of scarcity, is talc schist ; and most of the remainder are mixtures of sand and clay. The analyses showed that there is no food value in these earths owing to the presence of only infinitesimal amounts of organic matter and soluble mineral salts.

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List of papers bearing on Economic and Industrial Chemistry.

CASH, T., & DUNSTAN, W. R.	The Pharmacology of Ind-aconitine and Bikh-aconitine. (*Proc. Roy. Soc.*, 1905, 76, 468-490.)
DUNSTAN, W. R., & ANDREWS, A. E.	Ind-aconitine. (*Journ. Chem. Soc.*, 1905, lxxxvii, 1620-1635.)
DUNSTAN, W. R., & ANDREWS, A. E.	Bikh-aconitine. (*Journ. Chem. Soc.*, 1905, lxxxvii, 1635-1649.)
DUNSTAN, W. R., & HENRY, T. A.	The Aconitine group of Alkaloids. (*Journ. Chem. Soc.*, 1905, lxxxvii, 1650-1656.)
ETARD, A., & WALLER, E.	Pyrogenetic decomposition of Lac Resin. (*Comptes rend.*, 1905, 140, 1603-1606.)
FELDHAUS, J. . .	The distribution of Alkaloids in the organs of D. Stramonium. (*Arch. Pharm.*, 1905, 243, 328-348.)

GRESHOFF, M. . . Determination of the value of Gambier or Yellow Catechu. (*Chem. Centr.*, 1905, 2, 993.)

GRESHOFF, M. . . The presence of Prussic Acid in Gynocardia seeds. (*Chem. Centr.*, 1905, 1, 683.)

GUIGNARD, L. . . Experiments in the cultivation of Phaseolus lunatus. (*Comptes rend.*, 1900, 142, 545.)

HARTWICK, C., & HAKANSON, G. Glyceria fluitans. (*Zeitschr. Natur. Genüssm.*, 1905, 473-478.)

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HOOPER, D. . . Saltpetre. (*Agricultural Ledger*, No. 3, of 1905.)

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HOOPER, D. . . Storax testing. (*Pharm. Journ.*, 76, 107.)

HOOPER, D., & MANN, H. H. Earth-eating and the earth-eating habit in India. (*Mem. Asiat. Soc. Beng.*, i, No. 12, 249-270.)

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LEATHER, J. WALTER . The rate of Hydrolysis in the Septic Tank. (Paper, at the 6th International Conference of Applied Chemistry, Rome, 1906.)

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MANN, H. H. . . The fermentation of Tea, Part I. (*Indian Tea Assoc.*, 1906, No. 1.)

MANN, H. H. . See *Hooper*.

PERKIN, A. G. . . The constituents of Gambier and Acacia Catechu. (*Journ. Chem. Soc.*, 1905, lxxxvii, 398-404.)

PERKIN, A. G. . . Cyanomaclurin. (*Journ. Chem. Soc.*, 1905, lxxxvii, 715-722.)

POWER, F. B., & BARROWCLIFF, M. The constituents of the seeds of Gynocardia odorata. (*Journ. Chem. Soc.*, 1905, lxxxvii, 896-899.)

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ASTRONOMY.

BY

G. T. WALKER, M.A., Sc.D., F.R.S.,

Director-General of Observatories.

Solar Physics.—Research in solar physics is carried on under the direct control of the Government of India at Kodaikanal, the Director being Mr. Michie Smith. The chief instruments there are :—

(*a*) A spectroheliograph made by the Cambridge Scientific Instrument Company, the object of which is to make photographs of the sun using the light emitted by one chemical element only.

In this apparatus a stationary image of the sun is made by a 12-inch triple-achromatic lens of 20-foot focus fed by an 18-inch Foucault siderostat. Close up to the image and somewhat longer than its diameter is the narrow vertical slit of a spectroscope arranged in such a manner that the light which has passed horizontally through the collimating lens shall be deflected through two right angles by two prisms and a mirror and so emerge from the camera lens parallel to its original direction. This light then falls upon another vertical slit which can be moved from side to side and fixed in such a position as to allow light of any desired wave length to pass through. In the Kodaikanal spectroheliograph the collimating and camera lenses, each of 5-inch aperture and 6-foot focal length, together with the prisms and slits are attached to a rigid framework, while immediately in contact with the slit last described is a stationary photographic plate within a fixed camera. The rigid framework is capable of motion in a horizontal plane in such a manner that the primary slit may pass uniformly across the image of the sun while the secondary slit will move at an equal rate across the sensitised plate ; and as in each position an image will be formed at the second slit by light of the desired wave-length and no other light can emerge, the result of the movement upon the plate is a complete image of the sun in monochromatic light. At present the H and K lines

of calcium are largely used on account of the convenience afforded by their width and the fact that the centre of the dark line is frequently "reversed," *i.e.*, is bright instead of dark, indicating that the calcium vapour is abnormally hot in the higher levels of the solar envelope. A photograph so obtained shows bright clouds—called flocculi—of calcium vapour scattered about over the sun and gives a large amount of information that is not otherwise obtainable. Further, by causing the slits to move more slowly the exposure may be lengthened sufficiently to give photographs of the "prominences" projecting from the sun's margin.

One ingenious method is, like the instrument itself, due to Professor Hale. He pointed out that as the effect of pressure is to widen lines, the calcium radiation whose wave length is that of the margin of the H or K line has come from regions which are subject to high pressure and are presumably low down in the sun's envelope: accordingly by setting the secondary slit near the margin of the H or K line we secure a photograph showing the calcium vapour low down, while if the slit be upon the centre of the line the picture includes the calcium vapour that is nearer to the outer margin of the sun's envelope. We are thus enabled, as it were, to get sections showing the temperature distribution of the gases at different elevations. Such photographs usually show larger diameters in the flocculi at higher than at lower elevations, so that these tend to have the shape of an inverted cone.

Some difficulty has been experienced with the definition of the spectroheliograph, but methods have been adopted for overcoming this, and the quality of the photographs has improved materially during the past year.

(*b*) Two 6-inch refractors, with one of which an Evershed spectroscope has been used since November 1904.

These are used for visual examination of the sun and for spectroscopic study of spots and prominences.

(*c*) A spectrograph consisting of an 11-inch polar siderostat with a 6-inch Grubb lens of 40-foot focus and a 4-inch concave

grating of 10-foot focus mounted on Rowland's plan. A plane grating with collimator and camera lenses of 8-foot focus can be substituted for the concave grating.

This apparatus has been out of use owing to pressure of other work, but it is intended to bring it into use when the staff receives a material increase of strength from the arrival of Mr. Evershed as Assistant Director in December next.

(*d*) A photoheliograph by Dallmeyer.

With this a photograph of the sun in ordinary light is made daily when possible. Originals are sent to Greenwich for the use of the Solar Physics Committee for those days for which photographs are not available from Greenwich or Dehra Dun.

2. In addition to the use of the spectroheliograph and photoheliograph the routine work includes visual examination of sunspots and faculæ, observations of widened and displaced lines in sunspot spectra and spectroscopic observations of prominences. A monthly article describing the solar activity is contributed to the 'Monthly Weather Review,' while for more technical purposes the publication of bulletins of the observatory has been commenced. Of these, seven have appeared, and the eighth, which will include the spot spectra observed up to the end of June 1906, is now in preparation.

Among the features observed during the year have been the similarity of the prominences as seen in the spectroscope, using the light emitted by glowing hydrogen, with those photographed with the spectroheliograph in calcium light; the chief difference appears to be that the latter are more continuous than the former, in that while in many cases the hydrogen prominences consist of a network of fine jets or filaments, the interstices are largely filled up in the calcium photographs. It has also been observed that in the case of spots which disappear temporarily flocculi remain to mark the locality.

This observatory has undertaken to take part in the scheme now being drawn up by the 'International Union for Solar Research.'

There is also at Poona, under the Government of Bombay, the Takhtasingji Observatory, where research in solar physics is carried on by Mr. Naegamvala. The chief apparatus are:—

(*a*) A Foucault 12-inch siderostat with an 8-inch image lens and a spectroscope with a 1½-inch Rowland grating. With

these daily observations are made of the twelve most widened lines in sunspot spectra in the region D—F. The results have been forwarded monthly to Sir Norman Lockyer, and very close agreement of these observations with those at South Kensington has been attained. Proposals for an improvement in the equipment are under consideration.

(*b*) An equatorial refractor with a Cooke 6-inch triple photovisual lens. This is provided with two 45° objective prisms, and a prominence spectroscope with a Thorpe transmission grating has been constructed locally for attachment to it.

(*c*) An equatorial reflector with a 20-inch mirror by Common. A focal plane spectrograph was received from Sir H. Grubb during the year, but as the dome has been under repairs for the greater part of the year the telescope could not be remounted and the instrument brought into use.

At Dehra Dun, under the Survey of India, the photoheliograph has been in regular use, and photographs of the sun have been transmitted to Greenwich for measurement in the joint series with those of Greenwich and Mauritius.

METEOROLOGY.

BY

GILBERT T. WALKER, M.A., Sc.D., F.R.S.,
Director-General of Observatories.

Study of the Conditions determining the Monsoon.—It has lately been realised that the area over which the weather is connected with that of India is considerably larger than had been supposed. The idea of such connections was foreshadowed by Hann in 1879, and in the same year an opposition in pressure between Siberia and the Indo-Malayan region was pointed out by Blanford. A number of relations were given in 1897 by Hildebrandsson, including the similarity of the pressure variations of a few months' duration of Paris, Berlin, and the Azores, and their opposition to those of Iceland; the opposition of the variations of Sydney and Buenos Aires was also noticed.

In 1902 the Lockyers drew attention to the opposition in pressure between Cordoba (Argentine Republic) and India, the variations of the latter of which resembled those of the number of solar prominences; and in the succeeding year Bigelow published maps of the world for temperature and for pressure in which regions were classified according as their variations were similar or opposite to those of solar prominences. That portion of this work which deals with pressure was again discussed by the Lockyers in 1904, and their results agreed on the whole with Bigelow's. A cursory glance at the curves representing pressure in South America and Indian rainfall would suggest a close connection, but there are very many curves in which visual impressions are not to be trusted; the simpler numerical methods of statistics have therefore been habitually employed and correlation coefficients calculated.

Preliminary analysis has thus shown that abundant monsoon rainfall in India is on the average associated with numerous sunspots, with low pressure in India, Zanzibar, Mauritius, and Australia, and with high pressure in the Argentine Republic, the Azores, and possibly in the Sandwich Islands: in Siberia pressure tends slightly to be high in winter and low in summer. In these years temperature tends to be low in India, Siberia, and the Argentine Republic, and high in Australia, especially in the interior: rainfall is also scantier than usual at Zanzibar. When relationships with years of numerous sunspots are examined it is found that all the above tendencies occur, with the exception that temperature in Australia has an uncertain tendency to be low in their summer and high in their winter, instead of being high all the year round.

Although Indian rainfall does tend to increase with the number of sunspots, the connection will only account for something like a sixth of the variations in the annual rainfall, and about five-sixths remain to be explained. Thus, while the annual rainfall departures are largely independent of the number of sunspots, the striking fact remains that the characters and degrees of relationship of sunspots and of Indian rainfall with features in distant parts of the earth are largely the same. This suggests that as the effects associated with sunspots are presumably due to variations in some cosmical influence, such as heat radiation from the sun, the number of ions discharged from it or the electric conductivity of space within the solar system, the same cause may be responsible for that part of the Indian rainfall variation which

is not determined by sunspots. It has often been suggested that the increased rainfall over a large part of the earth associated with numerous sunspots was due to increased vigour in the circulation of the atmosphere, and that as the air currents are due to the sun's heat, there must be more heat radiated from the sun at times of numerous sunspots; Blanford argued further that, since at times of increased rainfall there is more cloud and greater evaporation of moisture from the ground, there is nothing paradoxical in the reduction of temperature which occurs over the greater part of the land areas of the earth. It was pointed out by Hann, however, that the air as a whole must be hotter or the air currents would not be intensified; and this objection can only be met if it is shown that the greater coolness extends to only a small height above the ground, this being rendered possible by the great opacity of water vapour to heat radiation.

In order to throw light on this point it seemed advisable to examine the temperature data of those parts of the world where cloud is most rare and other interference is unlikely, and of these the observations made at Charlotte Waters and Alice Springs in the centre of Australia are available since 1893 and 1878, respectively. The result found is that in years of many sunspots it is slightly hotter than usual from June to August and cooler than usual from December to February, the former effect being the larger: on the mean of the year it is slightly hotter. With Indian rainfall, however, the relationship is much closer; it is on the average hotter in central Australia in years with a good Indian monsoon, and over half of the variations of rainfall correspond with the central Australian temperature departures. Although some support is thus given to the view that the heat radiated from the sun is larger in years of abundant rainfall, it must be admitted that the evidence is uncertain, and much further examination of the point is desirable.

In addition to the above relationships a number of others have been examined, with the object of discovering the physical explanations of the results empirically obtained, and data are being accumulated for further investigations.

Charts of the Indian Ocean.—The kind co-operation of the meteorological offices at London, Washington, Hamburg, and Mauritius for providing originals or copies of ships' logs had been secured, but it is only lately that the data from all these offices, in addition to

those from Calcutta and Bombay, have arrived. Experience has shown that the difficulties in connection with this work had not beeu exaggerated; even when the data of a month have been put together, a large area in the centre of the Ocean contains no readings, and elsewhere the largeness of the average errors of individual readings, combined with the smallness of the number of readings available, makes the monthly mean in many parts of the map extremely uncertain. Under such conditions the accidental and subjective elements in the final result must be larger than is desirable, and considerable care will be necessary in order that results of any value may be obtained.

Investigation of the Upper Air.—*Kites.*—During the year some progress has been made with the work of ascertaining, by means of meteorographs carried up by kites, the condition of the free air at some distance above the earth's surface. For this purpose two visits were paid to Belgaum, in May and June and again in August and September, and on each occasion flights were made by means of box and diamond-shaped kites up to such elevations as were attainable in the winds prevalent at the time. In May and June the velocity of the wind during the experiments averaged about 12 metres per second, and, working with a hand-winding machine, heights of about 1,200 metres were reached by the instruments. At this time weather was as yet undisturbed by the conditions of the earlier advances of the monsoon, and the characters met with in the various strata were presumably representative of the usual dry weather of May in the Peninsula.

During the later work in August and September the monsoon was well established, and the records brought down by the kites from regions of the air in India, which were previously unexplored, have supplied definite information on points which had until then been subjects of theoretical discussion.

During this second visit an oil engine of 3 H. P. was used to drive a new wire-winding machine which had been made in the Sibpur College workshops and was then put into use for the first time. This machine is capable of holding about 16 kilometres of steel kite-wire of a breaking pull of 135 kg., and is arranged to respond almost instantaneously to a friction cone clutch through which the connection with the engine is made. Provision for a base station of a semi-permanent character was made at Belgaum

by the building of a stone shed to contain the engine and winding machine, and to protect them and the operators during work in the inclement weather of the rains.

A comparison of the atmospheric conditions in late May with those of late August is of interest, as showing the distinction between the characters of the pre-monsoon and the monsoon periods.

During the days of work in May the winds at Belgaum blew from between west and south-west near the ground, and changed in direction at higher levels with the usual clockwise rotation. On the 28th May the average velocity within 600 metres of the ground was 10·7 metres per second ; this increased to 13·4 metres per second at a level of 900 metres and then fell off to about 12·3 metres per second at 1,180 metres. Temperature gradients were −1·14°C. per 100 metres from the surface up to 1,000 metres, at which level a strong temperature inversion was encountered with a rise of +3·7°C. per 100 metres in the succeeding 150 metres ; the air in this region showed a sudden fall of relative humidity from 85 per cent. below to 23 per cent. above the stratum of transition.

On August 29th, when the most satisfactory flight of the month was made, the surface velocity was 16 metres per second, and this velocity fell off but little, if at all, through the strata which were penetrated ; the wind direction showed no appreciable variation with height as the kite rose on any given day, although considerable changes of direction of the whole wind system occurred during intervals of several days. The temperature gradients observed were then −1·56°C. per 100 metres near the surface, falling, however, to −0·66°C. per 100 metres between the levels of 300 metres and 1,670 metres, thus giving a mean gradient of −0·82°C. per 100 metres from the ground surface up to this level. As in May, an inversion was met with, occurring during the ascent at the height of 1,670 metres, the rise of temperature being about +2°C. in 300 metres or at the rate of +·067°C. per 100 metres. Above this again a rather strong falling gradient was resumed, at any rate up to 2,160 metres, equivalent to −1·1°C. per 100 metres : how much higher this rapid gradient extended it is not possible to say, for by the time the kite had risen further the level of the whole inversion layer had risen considerably and left the kite behind. Associated with this rise of temperature in the stratum of inversion occurred a fall of relative humidity from 94 per cent. to

19 per cent., and this perhaps marked the upper limit of the stratum of air from which monsoon rainfall was available in any appreciable quantity. The transition layer from wet to dry air underwent rapid and large changes of level, varying as much as 310 metres within an hour's interval, and the kite was crossed and recrossed in the course of the hour by the boundary of the humid layer; it was thus alternately soaked in rain-clouds and dried in air exceptionally free from moisture, conditions which led to warping and bad behaviour during flight.

The following table summarises the information relating to these two periods :—

Date of flight.	Height in metres.	Humidity, per cent.	Temperature gradient, °C. per 100 metres.	Wind velocity, metres per second.	Remarks.
28th May 1906 .	0	63		10·7	
	600	...			
	840	92	—1·05	13·4	
	900	...			
	1,000	85			Beginning of inversion stratum.
			+3·7		
	1,100	23			End of inversion stratum.
	1,180	...	...	12·3	
29th August 1906	0	80	—0·82		
	700	100			
	1,670	94	+0·67		Beginning of inversion stratum.
	1,960	24	—1·1	16	End of inversion stratum.
	2,160	19			
	2,420	...	...		

In addition to the kite work above described, an attempt was made in May to ascertain whether the presence of radioactive matter in the atmosphere at high levels could be detected by simple means. Metal plates were attached to the steel kite wire immediately below the

topmost kite to act as collectors of the positively electrified carriers of the radioactivity. That this action might be expected follows from the following considerations. The steel kite wire is invariably earthed by the operator during kite ascents in order that he may avoid the risk which would attend the manipulation at the winding machine of an insulated wire penetrating into regions of the air in which the potential differs greatly from that of the earth. The earthed wire necessarily remains sensibly at zero potential throughout its length, so that electric fields are produced in its vicinity where it passes through air which is not at zero potential. Fields of electric force so produced are frequently strong, and when, as is usually the case, the potential of the air has a positive value, the positively electrified carriers of radioactivity would under the influence of the electric forces travel towards and attach themselves to the exposed surface of the earthed wire and metal plates. In the experiments made at Belgaum the plates were of zinc sheet, in size about 15 cm. square. One only was exposed during each ascent, and on recovery was rubbed over on both sides by a chamois leather disc moistened with dilute ammonia. Adherent radioactive matter was thus transferred to the leather, and its presence detected by means of a gold leaf electroscope which had been under observation for some hours previously, and had thus had its natural rate of leak determined.

Very noticeable effects due to active matter attended the exposure of the electroscope to the influence of the leather disc after the plates had been rubbed by it, the magnitude of the result varying from day to day. At the time of this trial there were no means available for confining the exposure of the plate to any given stratum of air, nor of measuring the potential which determined the strength of the fields involved, so that it is impossible to say in what stratum of the 1,200 metres of air through which the kite passed the quantity of active matter was greatest, or its collection by the plate most vigorous.

During the second visit to Belgaum in August, it was found to be impossible to repeat these experiments in consequence of the stress of the ordinary work connected with kite-flying in the strong monsoon winds prevailing at that time.

Balloons.—Ascents of small balloons composed of very thin guttapercha tissue have been made as opportunity offered, and the courses of the balloons have been observed by means of two theodolites

separated by a distance which was in some cases 3·54 kilometres, and in others 2·88 kilometres ; from the data so obtained the heights and courses have been plotted, and the velocities of the air currents at various levels determined. Difficulties which were at first encountered in making these balloons in Simla have since been overcome, and the type now adopted is a sphere of 1·5 metres diameter made of 13 segments of guttapercha tissue cemented together by the application of benzoline. Each balloon when complete weighs 0·26 kg. and is provided with a guttapercha tube 4 cm. in diameter and 15 cm. long, through which the hydrogen, expanding during the ascent, makes its escape. The material of the tube is of the same thickness as that of the balloon, and being exceedingly flexible tends, in the event of the balloon turning upside down, to lie flat against it and to be self-closing, so that the escape of gas occurring in this position is no greater than is in any case entailed by the expansion which takes place during ascent. The balloons are completely filled with hydrogen and are liberated from one end of the base line ; they rise at about 4 metres per second or 9 miles per hour, and in the clear weather chosen for their flights do not as a rule disappear from sight until they have attained altitudes of from 7,000 to 9,000 metres above sea level, and have travelled to distances of 24 kilometres or more.

As the results of comparison of the records of flights made before and after the monsoon, it appears that very much greater velocities of the upper air currents occur in the former period, as much as 39 to 44 metres per second, or 90 to 100 miles per hour, having been noted at heights of 8,000 metres above sea level. After the monsoon the corresponding velocity is about 13 metres per second or 30 miles per hour.

The winds in the upper strata have varied from directions S. 70 W. to N. 30 W. during the several ascents hitherto made; but sufficient data have not as yet been accumulated for establishing a definite connection between the directions and velocities of the upper currents and the general weather conditions of India.

The Electrical Condition of the Air.—It has long been known that the frequency of occurrence of magnetic disturbances varies with the number of sunspots, violent magnetic storms often occurring when a large spot is visible ; and the same relationship holds, though to a

less complete extent, in the case of auroras. It is practically certain that the magnetic storms cannot be due directly to changes in the sun's magnetism, and it seems likely that both magnetic storms and auroras may be caused by an increase in the electric conductivity of space in the solar system or in the rate at which ions are shot off from the sun. In any case the fact that ions form nuclei for the condensation of moisture makes the investigation of the electrical conditions of the air of considerable importance for meteorology. For measurements of the changes of potential near the earth water-droppers have been installed at Simla and Calcutta, and the difference between the potential of the air at the point where the drops form and that of the earth is measured by means of a quadrant electrometer: at Calcutta a radium collector has also been employed in place of the water-dropper. An automatic recorder, working on a photographic principle, will shortly be ready for use in Simla in connection with this work of potential measurement.

On the subject of the natural ionisation of the atmosphere, an experimental enquiry has recently been begun in Simla by means of an Ebert's aspirated electroscope; of this the essential parts consist of a clock-driven turbine which induces an air-draught of known velocity through an earthed metal cylinder, in the axis of which is placed a conducting rod kept in permanent connection with an electroscope. The rod and electroscope are charged to a known potential by means of a Zamboni pile, and an electric field is thus produced between the axial rod and the outer cylinder. During the passage of air through this field the paths of the positive and negative ions assume under its influence curved forms which cause them to collide with and be retained by the cylinder and rod, respectively. The charge on an ion is a definite physical quantity, and it is therefore possible, by measurement of the loss of charge of the electroscope system when a known volume of air has been deprived of its ionic contents, to determine the density of their distribution in the atmosphere.

There is abundant experimental evidence that ions tend to become loaded up with matter, especially in a humid atmosphere, when they behave as nuclei for the formation of water-drops. It is certainly desirable that this condition of the ions should be investigated during the prevalence of different types of weather, and Ebert's apparatus provides means of determining the extent to which

atmospheric ions have become so loaded. In an extension of the cylindrical tube through which the air is drawn there is placed a second axial insulated rod, and this is so disposed with regard to the rest of the apparatus that the air passes first through the annular space between the extended cylinder and the rod and then reaches the system of tube, rod and electroscope which has already been described. The additional axial rod is kept at a known small difference of potential from the surrounding tube by means of a battery, and a certain proportion of the ions is extracted from the air by this weak field before the stronger field of the electroscope system is encountered. Having given the charge on the ions, the strength of the field, the draught velocity, the diameter of the cylinder and the length of the axial rod, it is then a matter of calculation to ascertain the proportion of ions present in the air which show any stated degree of loading. Certain observations of this kind have been in progress for some months, but there are not as yet sufficient data to render any remarks on them of value.

Publications.—In addition to the Daily Weather Reports published at Simla, Calcutta, Bombay, and Madras, the Monthly Weather Reviews, the Annual Summary, and various administrative pamphlets, the following memoir has been published during the year 1905-06 in the series of memoirs of the department:—

> An account of the preparations made for determining the conditions of the upper air in India by means of kites. By J. H. Field, Esq., B.A., Imperial Meteorologist.

The printing and publication by Messrs. Bartholomew of Edinburgh of the meteorological and climatological atlas of India, which had been prepared by Sir John Eliot, has been completed and the work has appeared.

A meteorological atlas of the Indian Ocean north of latitude 12° S. has also been prepared by Mr. Dallas and is being published by Messrs. Bartholomew. The data of pressure and winds are based on logs collected in India from 1893 to 1904, and the atlas contains monthly normal charts of the pressure, winds, sea currents, and tracks of storms, together with charts of typical storms, and statements of the chief features contained in the charts.

TERRESTRIAL MAGNETISM.

BY

GILBERT T. WALKER, M.A., Sc.D., F.R.S.,

Director-General of Observatories.

Magnetic Observatories.—*Bombay* (*Colaba and Alibag*).—The magnetic comparison between the original observatory at Colaba and the new one at Alibag, rendered necessary by the approaching institution of electric tramways at Bombay, had lasted two years and was brought to an end in March 1906; the series of magnetic observations which had lasted at Colaba for sixty years then terminated. The programme to be followed in computing and discussing the past records had been referred by the Observatories Committee of the Royal Society to a sub-committee and the recommendations finally adopted by the Committee were received in India in August 1906. Arrangements have been made for the necessary temporary staff for the computations and also for the magnetic comparison of two rooms in each of which a long series of observations had been made: during the single year common to these two series discrepancies had shown themselves, and it has been recognised as desirable to ascertain whether the discrepancies in question were of instrumental origin or had a real existence. The problem is complicated by the irregular character of the local magnetic distribution.

Dehra Dun, Kodaikanal, Barrackpore, and Toungoo.—Of these observatories, which have been established as base stations in connection with the magnetic survey, the first two were started in 1902, the third in August 1903, and the last in December 1904: they are all equipped with Watson autographic instruments for declination and horizontal intensity. Magnetographs for recording vertical force were erected at Dehra Dun in August 1905 and at Barrackpore in July 1906, and it is hoped that a third instrument which has just arrived will be established at Kodaikanal during the coming season.

The instruments for recording declination and horizontal force at the first three stations have behaved satisfactorily. At Toungoo, however, the horizontal force magnetograph had to be opened up, cleaned, and fitted with a new quartz suspension; since that time the

experiments for determining the temperature coefficient have given discordant results, owing probably to the system not having reached a steady state after the recent change, and these experiments will be repeated in December next. Troubles have also been found with the vertical force instrument at Dehra Dun, of which the temperature coefficient was large and could not be reduced. Corresponding difficulties had been experienced at Kew in connection with the similar instruments for Toungoo and Kodaikanal, and it is hoped that a new pattern of compensating bar which has been devised in England will make it possible to surmount the obstacles in question. The vertical force instrument at Barrackpore unfortunately showed defects in the driving clock, and, as prolonged repairs have caused considerable delay, the installation cannot be completed until November 1906.

The mean values of the magnetic elements at the observatories for 1905 are as follows :—

Dehra Dun	Declination	2°·39'·9 E.
	H. F.	·33383 C. G. S.
	Dip	43°·24'·2
Barrackpore	Declination	1°·18'·0 E.
	H. F.	·37242 C. G. S.
	Dip	30°·22'·5
Kodaikanal	Declination	0°·31'·9 W.
	H. F.	·37403 C. G. S.
	Dip	3°·16'·7
Toungoo	Declination	0°·48'·4 E.
	H. F.	·38675 C. G. S.
	Dip	22°·58'·3

The secular changes at the base stations for the period 1904-05 deduced from the mean monthly values are indicated by the following table of changes during a year :—

Dehra Dun	Declination	—0'·9
	H. F.	—22γ
	Dip	+6'·7
Barrackpore	Declination	—4'·4
	H. F.	+17γ
	Dip	+3'·0
Kodaikanal	Declination	+4'·7
	H. F.	+22γ
	Dip	+5'·6

Magnetic Survey.—The preliminary survey of India for which sanction has been given is planned to involve :—

(*a*) Observations for declination, intensity, and dip at about 1,100 stations, whose distance apart will be comparable with 35 or 40 miles, the "density" being one station to 1,300 square miles.

(*b*) Observations in successive years of the magnetic elements at 23 "repeat stations" in order to make possible the elimination of secular variation.

(*c*) Data from absolute and self-registering instruments at Alibag and the four special base stations already mentioned.

A beginning was made with field work in November 1901, and the operations up to the end of the year 1904-05 have been described in previous reports : by that time 809 stations had been visited and 22 repeat stations established. During the year under report field operations were extended by three detachments into Chota Nagpur, Orissa, the Agency Tracts of the Vizagapatam district (including Bastar and Jagdalpur States), and Eastern Bengal and Assam. With the exception of the last named, where the observer worked mainly along the railway system, difficulties of country, supply and transport made it impossible to maintain the more rapid progress of former seasons ; moreover, the observer working in Orissa and almost the whole of his detachment suffered severely from the climate, and were withdrawn from field work for two months. A fourth detachment was employed in filling up gaps in previous seasons' work, but was withdrawn early in March to observe at repeat stations. For these reasons the total number of new stations was 130 only as compared with 206 in the previous season.

A second Imperial officer, Lieutenant C. M. Browne, D.S.O., R.E., was posted to the party at the end of November, but was transferred in February. With the assistance, however, of the detachment alluded to above and a new detachment placed under the spare observer, the officer in charge was enabled to secure the visiting of all the repeat stations in addition to inspecting and carrying out comparative observations at each observatory.

The total number of stations occupied to date is 938 with 22 repeat stations. The field season commenced on the 20th October 1905, and the party proceeded to recess quarters on the 7th May 1906.

In the ensuing season one detachment will work in Eastern Bengal and Assam, one in the difficult country comprised between Lat. 18° and 22° and Long. 80° and 86°, while the remaining two will be employed in Burma.

During the recess the computations of the field work have been completed, and the tabulations and reductions of the base stations results for 1905 are also practically finished. Observations for log $\pi^2 K$ have been taken with the standard and field magnets and are under reduction at the present time. The field instruments were all compared with the standard at the beginning and end of the field season. As the direction and magnitude of the magnetic force at any point changes from year to year, it is necessary that in any magnetic survey the values should be given for some definite date, and as measurements must be made on days widely distant in time, it is necessary that corrections for these "secular changes" should be applied: these corrections are obtained from the fixed magnetic observatories and the "repeat stations." An attempt to obtain the secular changes in declination by using only approximate corrections proved unsuccessful, but it appears that easterly declination is decreasing and westerly increasing over the whole of India at a very small average rate, probably about 2 to 3 minutes per annum, being greater in the south than in the north of India. In horizontal force the secular change ranges from about $+23\gamma$ per annum in Bengal to about -35γ in North-West India and Sind; in dip the annual change varies from 3'·0 in Bengal to 7'·4 in South India. The values of the declinations found in India proper range from 3°·50' E. in the extreme north at Dargai (Malakand) to 1°·5' W. at Cape Comorin, the general trend of the true isogonals being from east to west. The isogonals have been plotted on a chart of the scale of 80 miles to the inch, and an inspection appears to show that most of the irregularities in the lines are confined to a region which is roughly indicated by the boundaries of the Deccan trap and the nearer outlying parts. There are, however, some strikingly abnormal values found outside this area of which the following are noteworthy:—

Ongole, 2°·10' E., where the normal variation is about 0°·0'.

Near Harpanahalli, 1°·55' W., the normal variation of the district being W. 0°·5'.

Near Kuvoy (Cannanore), 1°·35″ E., where about 0°·50′ W. would be expected.

Quilon, 0°·10′ E., the normal being 1°·5′ W.

Near Indore, 0°·20′ E., where the normal is about 1°·10′ E.

Near Pokaran (Rajputana desert), where the declination changes from 3°·5′ E. to 0°·15′ E. in 40 miles.

Ganges valley { Buxar 3°·35′ E. / Saran 0°·45′ E. } where the normal variation should be 1°·40′ E.

Of these, the values at Ongole and Harpanahalli are probably due to the known haematite ores of the former and the Sandur magnetites in case of the latter.

Observations for determining the moment of inertia of the survey magnets have been carried out during the recess season with the inertia bars to which reference was made in last year's report.

The magnets at Toungoo and Barrackpore Observatories have not yet been tested. This will be done in the ensuing field season. The work has proved very arduous, involving the opening up of old computations for the correction of erroneous values for expansion and determination of the causes of the differences found in previous years. It is, moreover, disappointing to find that series of observations on different days with the same magnet, while affording very accordant results *inter se*, give largely discordant mean values. For this reason there is some uncertainty as to the correctness of some of the mean values of former years when observations were often confined to a single day. It seems probable, therefore, that a better mean result will be obtained by taking several series of observations with each magnet on different days and weighing them by means of their probable errors, irrespective of the accordance or otherwise of their mean values, provided there are no good reasons for rejecting any particular set or sets of observations. Observations are still in progress to this end, though begun early in July, and until these are completed it would be hazardous to attempt to draw any final conclusions.

As regards the field magnets, it is satisfactory to note that none appear to have lost any appreciable weight.

The balance indented for last year has arrived, and will be used to weigh the magnets before the beginning of the approaching field season.

GEOLOGY.

BY

T. H. D. LATOUCHE, B.A., F.G.S.,

Superintendent, Geological Survey of India.

General Geology.—Four parties were engaged during the year in extending the mapping of the geology of the country. These were employed in Baluchistan, Central India, the Central Provinces, and the Northern Shan States of Upper Burma. In the course of economic and other investigations additions have also been made to our knowledge of the Geology of Bundelkhand, of Bhutan, and of the Tertiary rocks in Burma and Northern Kashmir.

In Baluchistan a large area was examined in the Sarawán, Jhalawán, and Mekran provinces of the State of Kelat, and in the State of Las Bela. The numerous hill-ranges of this region consist of sedimentary rocks extending in age from Carboniferous to Pliocene. The area is divided in two regions: a western one including almost the whole of the Mekran with some of the adjacent parts of Sarawán, Jhalawán and Las Bela, occupied almost entirely by shales and sandstones known in the publications of the Geological Survey of India as the Kojak or Mekran beds, and corresponding with the Oligocene "flysch" of Europe; it has therefore been called the "flysch region"; and an eastern region including the greater part of Sarawán, Jhalawán, and Las Bela, consisting largely of limestones, those of the Oligocene, Eocene, and especially Jurassic, being particularly massive; hence it has been called the "calcareous region." By means of the palæontological data obtained, all these geological formations have been classified more accurately than had hitherto been possible, and brought into perfect agreement with the European standard of classification, which has been found completely applicable to Baluchistan.

In Central India mapping was proceeded with in the Narsingarh, Rajgarh, Kilchipur, and Indore States. The country was found to consist mainly of Deccan trap, with small caps of Laterite. In Narsingarh State a massive Intertrappean limestone was discovered, containing well preserved specimens of the Gasteropod genus *Physa*, already recorded from these beds in the Central Provinces.

The survey of hitherto unmapped portions of Eastern Bhopal was completed and the work was extended into the Narsingpur and Jubbulpur districts of the Central Provinces with the object of correlating the Vindhyan strata of Bhopal with those of Baghelkand.

Mr. Vredenburg's survey of the Vindhyan rocks in Bundelkand, in connection with the examination of the diamantiferous conglomerates in the Panna State, has led him to propose a new classification for that system. Instead of the division into Upper and Lower Vindhyan, the former consisting of three series, the Bhandar, Rewa, and Kaimur of Oldham and Mallet, Mr. Vredenburg proposes to unite the Kaimur and Rewa in one series, thus forming one group consisting mainly of sandstones separating two groups of shales and limestone with subordinate sandstone. For the two main divisions of the system he proposes the names Bhander and Ken, the former being divided into the Betwa series of sandstones and the Haveli series of shales and limestones. The Ken division consists of the Tons series (including Rewa and Kaimur), mostly sandstones, and the Son series, corresponding with the Lower Vindhyans. This classification certainly has the merit of being more symmetrical than the older one, but it remains to be seen whether it can be applied to the whole area covered by the Vindhyans, large portions of which are still unmapped.

In the Central Provinces the south-eastern parts of the Bhandara district (Atlas Sheet, 72 S.E.) were surveyed, the rocks met with being Vindhyans, micaceous and chloritic schists (Dharwars), and granites and gneisses (Archæan) with some altered dolerites, and basalts, the last being intrusive in and younger than the Vindhyans. Part of the season was occupied in sorting the fossil and mineral collections in the Nagpur Museum, and in arranging and cataloguing the material retained for exhibition.

In Burma the survey of the geology of the Northern Shan States was carried to the north-eastern border of the Southern Shan States in Kehsi Mansam and Möng Küng. Here a fairly complete series of the formations already recorded from the Shan plateau was found, confirming the conclusions already formed as to their stratigraphical succession. Incidentally the position in the series of some of the formations, *e.g.*, the Napeng shales and Fusulina limestone, which has given rise to a certain amount of controversy since the survey of these hills was first undertaken, has been more or less satisfactrilyo

determined. The description of the fossils from the older Palæozoic rocks of the plateau has now been completed and will shortly be issued in the Palæontologia Indica. The fossils from the carboniferous Fusulina limestones, and from the Mesozoic formations are also under description in Europe, and the results of these investigations are expected within a few months.

Opportunity was taken of a visit of the Political Officer in Sikkim to the Bhutan hills north of Gauhati in Assam to fill in one of the gaps in the geology of the Himalayas north of the Brahmaputra valley. The formations met with were similar to those already described from the Darjeeling and Buxa areas on the west, and the Aka and Daphla hills to the east. Proceeding into the hills from the south a broad band of Siwalik sandstones and conglomerates, with strings of lignite, is first crossed, followed by a narrower band of Gondwana rocks, with intensely crushed seams of coal. These are succeeded by the Buxa and Daling series of Mallet, the former on this section consisting mainly of massive quarzites, and dolomites with beds of gypsum. The Dalings consist of greasy fissile slates and schists, sometimes carbonaceous or graphitic.

During the course of his enquiry into the oil industry in Burma Mr. Pascoe surveyed two previously little known anticlinal folds in the Myingyan district, known as the Gwegyo and Kabat anticlines. The prospects of obtaining oil beneath these folds aresaid to be promising, and drilling operations are now in progress. An account of these anticlines will appear shortly in the *Records*.

Various additions of great interest to our knowledge of the geology of the middle Indus valley in Kashmir have been made by the officer deputed to examine the glaciers in that country, but a full report on these has not yet been received. It is evident that Mr. Lydekker's *Memoir* on the geology of Kashmir, valuable as it may be, has not exhausted the subject, and that many interesting problems in the geology of that country await solution when the survey of it in greater detail is taken up.

Palæontology.—In the course of the year Professor C. Diener's Memoir on the Fauna of the Tropites-Limestone of Byans was published as Vol. V, Ser. XV of the Palæontologia Indica. From this horizon 168 species are described, among which 155 are ammonites, and of the latter 102 species are peculiar to the Tropites-limestone

of Byans, though a very large percentage is allied to European forms. The peculiar interest of the Tropites-limestone consists in the fact that although the bed is only 3 feet in thickness the fauna contains species either closely allied to or identical with those found in two distinct stages, the carnic and noric stages respectively, in the Mediterranean province of Europe as was first pointed out by the late Dr. A. v. Krafft. Professor Diener rejects the supposition that this mixture of forms is due to a passage between the carnic and noric stages, or to accidental mixing of the collections from various localities, but considers that it may be explained by a deficiency of sedimentation in the Byans area during the period covered by the two stages.

Mr. Vredenburg has described a new species of Nummulite from Kachh, which he has named *N. Douvillei*, and has worked out the zonal distribution of the Indian Nummulites, which occur in four successive geological series separated from one another by unconformities. The results of his work will appear in the forthcoming number of the *Records*.

A collection of Upper Triassic fossils from the Pishin District, Baluchistan, has been described by Dr. Diener in Vol. XXXIV, Part I, of the *Records*. The fauna is very scanty, and consists of a Lamellibranch, *Monotis Salinaria* Schloth, characteristic of the noric Halstatt limestone of Europe, and several ammonites, probably belonging to new species, only one of which, *Rhacophyllites Vredenburgi*, Diener, is sufficiently well preserved to be worthy of specific designation. The balance of evidence is in favour of the correlation of these beds with the noric stage of the Alpine Upper Trias.

Physical Geology.—A request was made last year by the International Committee for the study of Glaciers that the Government of India should co-operate in the attempt that is now being made in all parts of the world where glaciers exist, to discover the conditions regulating the secular increase or decrease of the ice, and the relation of such movements to changes of climate. For this purpose three parties were sent up during the recess season to the Himalayas of Kumaon, Lahoul and Kashmir respectively, with instructions to mark in a permanent manner convenient fixed points with respect to the present positions of the lower ends of certain selected glaciers, also to make large scale plans on which the position of the marks are shown, and to take photographs for

comparison with future observations. It is hoped that when these preliminary measurements are complete the assistance of travellers and sportsmen may be secured in order that a more or less continuous record may be kept up of the movements of these glaciers. Offers of assistance have already been received from the Resident in Kashmir and from Doctors Arthur and Earnest Neve, both of whom have for some time made a study of the glaciers in that part of the Himalayas.

The determination of the quantity of silt carried down by the Indus has been carried on steadily throughout the year. Samples of the silt-laden water were collected once a week during the dry season, and twice weekly during the rains, at two points, *viz.*, at Bukker, where the river is confined in a narrow, rocky channel, and at Kotri, where it is spanned by a railway bridge. The samples were despatched regularly to the Geological Survey Laboratory in Calcutta, where the silt was allowed to settle, the clear water decanted off, and the remainder evaporated. The silt was then weighed and the results recorded. Determinations were made at the same time of the amount of soluble salts dissolved in the water. At the end of the year the results will be tabulated and discussed.

Seismology.—The work of digesting the large mass of data supplied from all parts of the country regarding the destructive earthquake of 4th April 1905 in the Punjab Himalayas is now nearing completion and a *Memoir* on the subject is being prepared.

A smart shock of earthquake was felt in Calcutta at 11 A.M. on Saturday, the 29th September, 1906. Though very little damage was caused, except a few cracks in walls, the shock is of considerable interest because of its extremely local character. It appears to have been confined entirely to the immediate neighbourhood of Calcutta, and was not felt even at Dacca. It had no connection therefore with the after shocks of the great earthquake of Assam. In Dr. Oldham's Catalogue of Indian Earthquakes (Memoirs, Geol. Surv. Ind., Vol. XIX, Part 3) only 27 earthquakes are recorded from Calcutta and its immediate vicinity alone, and of these some of the shocks felt prior to 1829 may have been due to the reverberation of severe shocks originating at a distance, in Assam for instance, which till that time was little known. No Calcutta shocks are recorded between that year

and 1845, and only 13 between 1845 and 1869, when the Catalogue was compiled. Most of the shocks recorded appear to have been of the same character as that of September 29th, namely, short and distinct, but not very destructive, except the first on the list, that of October 11th, 1737, which was accompanied by a violent hurricane, which latter seems to have been responsible for most of the damage done. A few of the shocks are said to have been vertical. It is considered possible that these local shocks are due to movements in the beds of silt underlying the delta.

Circulars have been sent out asking for particulars of the time and severity of the shock in the localities where it was felt, and the replies, when received, will be discussed in the *Records* in due course.

Economic Mineralogy.—Satisfactory progress in the mineral development of the country is still being maintained. The total value of the minerals raised, for which trustworthy returns are available, rose from £5,357,840 in 1904 to £5,707,956 in 1905, while the number of licenses for exploring, prospecting and mining issued rose from 151 to 189. The greatest activity in prospecting was shown in the Central Provinces, where manganese is the principal mineral sought for, and in Madras, where gold and mica received most attention.

Borings with diamond drilling machinery, designed to test the quality of the copper ores which occupy a broad belt of country in Singbhum, in order to discover whether they are worth exploiting as a source of sulphides in connection with the utilisation of the waste products from the projected installation of iron smelting works on a large scale at Sini on the Bengal-Nagpur Railway, have been in progress since last January. The ancient workings were traced for sixty miles, and after the lodes exposed at the surface had been sampled in the field with a portable assay furnace, several sites were fixed on for drilling operations. The first boring was situated at Kodomdia, near Amda station, and passed through a three foot lode consisting of stringers of chalcopyrite in a quartzose gangue, at a depth of 400 feet. Another boring at the same locality, designed to reach the lode at a depth of about 1,000 feet is now in progress, and another at Regardih, about seven miles to the westward of Kodomdia, has just reached what appears to be the surface of the lode at a depth of 190 feet.

A survey was also made to determine the economic value of the iron, copper, mica and other deposits in part of Bankura. A preliminary report on this subject has been furnished to the Government of Bengal.

The gold-dredging concessions granted on the Chindwin and Irawaddi rivers, and on the Nam-ma stream in the Northern Shan States were visited, and a report on them is now under the consideration of the Government of India. The ancient silver-lead mines of Baudwingyi, to the east of the Ruby Mines, which were worked on a large scale by the Chinese up to the middle of the last century, were also visited, and a report on them has been submitted. Active operations for the exploitation of these mines are now in progress.

The existence of gold in the streams draining the Loi Twang range, on the crest of which the three sub-states of Möng Tûng, Kehsi Mansam, and Möng Küng unite, was brought to the notice of the Government of Burma by the Sawbwa of Hsipaw last year. An examination was made of the gold-bearing deposits, but the average value was found to be very low, and not such as to encourage operations on a large scale for the recovery of the gold.

The diamond mines of Panna State in Bundelkhand form the subject of a paper published in the June number of the *Records*. The principal source of the diamonds is a conglomerate separating the Kaimur sandstones from the Rewa shales, *i.e.*, in the middle of the Tons series of Vredenburg, locally known as *mudda*. The methods of working the deposit are very primitive, either by pits, which are sometimes sunk to a depth of more than 50 feet, through the overlying strata, or by shallow workings, in places where the diamantiferous conglomerate is exposed at the surface, and in alluvial deposits. The diamonds are considered to have been derived from the granite area of Bundelkhand, perhaps from the innumerable basic dykes of Bijawar age which traverse the granite. The colour of the stones varies from white, which occurs in the largest proportion, to brown, green, yellow and grey, while a very small proportion is stained with hæmatite. Stones of over two carats in weight are rare.

Suggestions are made for increasing the production by sinking deep shafts at a distance from the outcrop and mining the deposit as if it were a coal-seam; and in the case of the shallow workings a systematic plan of long trenches is proposed, a certain width being

opened up each year, and the waste material dumped in the trench of the previous year. This would prevent the waste of labour that now occurs, when a new pit is opened, in removing the rubbish thrown out from former workings.

Advantage has been taken of the visit of the parties sent up to Kumaon and Lahoul in connection with the glacier enquiry to investigate reports that have been received from time to time of the occurrence of minerals in those districts. Thus the copper ore deposits of Kumaon have been examined, but in no single instance have they been found to be of any practical value. The reported existence of a lode of copper ore 60 feet thick in the Girthi valley north-west of Milam, has been shown to be due to insufficient evidence, nothing being found but shallow diggings in a talus heap in search of scattered blocks of cupriferous sandstones. The asbestos reported to occur near Pithoragarh is likewise valueless, and the coal-seams on the new cart road between Kotdwara and Lansdowne have been shown to be mere coaly strings imbedded in the Tertiary rocks, and are of no importance.

In Lahoul a bed of antimony ore close to the Shigri glacier, for mining which a concession has been granted, was visited, but the result of the examination has not yet been reported.

An exhaustive enquiry was made into the conditions under which the petroleum industry is being carried on in Burma both by the Native well-owners, or Twinzas, and by the various companies engaged in the production of the crude oil in the three principal oil fields, Yenangyaung, Singu and Yenangyat. Certain recommendations have been made with regard to the future position of the Twinzas, and their relations with the companies, and the conditions under which future concessions should be granted. These are now being considered by the Government of India.

In addition two newly discovered anticlinals, beneath which it is hoped that a store of oil will be discovered by boring, situated in the Myingyan district, were surveyed. Reports on these will be published in the *Records* of the Geological Survey in due course.

In Baluchistan a coal-seam in the vicinity of Johán in Sarawán was visited by Mr. Vredenburg, and some old copper, lead and antimony mines near Khozdar, by Mr. Tipper. All these minerals are too poor in quality and too remotely situated to be worth extracting under

present conditions. The coal occurs in the Ghazij group (eocene), and is therefore of the same age as the other coal-seams of Baluchistan and the Punjab. The metallic ores occur in connection with intrusions of the age of the Deccan Trap (Senonian). Magnesite occurs in connection with these intrusions south of Wad in Jhalawán. Sulphur deposits were examined in Kachhi by Mr. Tipper and in Las Bela by Mr. Vredenburg. The sulphur has in both instances been deposited by sulphurous springs and is associated with gypsum and alunogen, a compound of sulphur trioxide and alumina. Large quantities of barytes were discovered by Mr. Tipper in the Lower Cretaceous beds.

Some coal-seams occurring in the foot hills of Bhutan, to the north of Gauhati in Assam, were examined and a report on them published in the *Records*. The coal is of Gondwana age, but like all the coal of the Sub-Himalayas belonging to that period, has suffered so intensely from crushing that its value as fuel has greatly deteriorated. The greatest thickness of coal observed was 3 feet, but owing to the crushing of the rocks it has been squeezed out into lenticular patches, thus greatly increasing the difficulty of prospecting and mining operations. Even in the Darjeeling area, where seams of coal of the same character, but of much greater thickness and in a more accessible position occur, it has been found impossible to work them with profit. The chances therefore of the Bhutan coal being worked are very problematical, except on a small scale by the natives for sale to tea gardens.

Another of the small coal fields in the Jammu State, that of Dandli in the Kotli Tehsil, has been described in the *Records* by Mr. C. M. P. Wright. The coal is of the same age and character as that previously described by Mr. LaTouche in the Sangar Marg and Mehowgala fields, and by Mr. Simpson in the Ladda field. The seams are highly inclined, and very irregular, the coal is of poor quality, and considering the distance from the railway and the absence of local demand, the field offers no inducement to exploitation.

GEODESY.

BY

LIEUT.-COLONEL S. G. BURRARD, R.E., F.R.S.,
Superintendent, Trigonometrical Surveys.

On Himalayan Heights.—Observations of Himalayan heights have been carried on throughout the year from stations near Dehra Dun. It is hoped that valuable information will be derived from a long continued series of observations, and it is proposed to persevere with them. No progress will, however, be possible until our knowledge of atmospheric refraction has been improved, and upon this phenomenon attention must for the present be concentrated. As was explained in the report of last year, it is possible to reduce errors of height due to refraction by shortening the rays. Refraction is erratic on long rays only, and if the heights of peaks be determined by successive shots of ten miles, the uncertainties that now exist will disappear. But this course is not likely yet to be practicable; we cannot approach within a hundred miles of many of the Nepal and Bhutan peaks, and to carry chains of triangles into the mountains towards all peaks would be impossible on the grounds of expense. Although, then, the errors due to refraction will disappear when short rays are introduced, we are limited at any rate for the present to the use of long rays, and we have to make the most of them.

In correcting heights for refraction computers introduce a number, which acts as a measure of the refraction. The great difficulty is to determine what that number should be. In calculating the Karakoram heights Colonel Montgomerie used a refraction coefficient of 0·05; in dealing with the Sikkim peaks Sir Andrew Waugh used a coefficient of 0·08. That is to say, Waugh assumed that the images of the peaks were being raised by refraction considerably more than Montgomerie did.

Waugh using 0·077 obtained a height of 28,146 feet for Kinchinjunga; Montgomerie using 0·047 obtained 28,250 feet for Peak K².

In the following table are calculated the heights of the second and third highest peaks of Asia on different assumptions of refraction:—

TABLE I.

Assumed coefficient of refraction.	THE RESULTING HEIGHT OF	
	K^2 observed from high altitudes.	Kinchinjunga observed from low plains.
	Feet.	Feet.
0·10	27,649	27,872
0·09	27,756	27,981
0·08	27,864	28,090
0·07	27,972	28,198
0·06	28,079	28,307
0·05	28,187	28,416
0·04	28,295	28,525
0·03	28,403	28,634

Here we see that on every assumption of refraction Kinchinjunga is the higher. But refraction varies with atmospheric pressure, and whilst Waugh observed Kinchinjunga from the plains of India, Montgomerie observed K^2 only from stations of 15,000 and 17,000 feet. Montgomerie was then right in using a smaller coefficient than Waugh, but we cannot yet say whether the difference should have been as great as it was. It is not possible at present to state definitely which of the two mountains is the higher, K^2 or Kinchinjunga, but it is probably Kinchinjunga.

Mount Everest was observed from six different stations in the plains of Bengal, and the following heights were obtained :—

TABLE II.

Height of Mount Everest as observed from the plains of India.

Station of observation.	Height of station of observation.	Distance from Mount Everest.	Coefficient of refraction.	The resulting height.
	Feet.	Miles.		Feet.
Jirol T. S. . . .	220	118·661	0·07	28,991·6
Mirzapur „ . . .	245	108·876	0·07	29,005·3
Janjpati „ . . .	255	108·362	0·07	29,001·8
Ladnia „ . . .	235	108·861	0·07	28,998·6
Harpur „ . . .	219	111·523	0·07	29,026·1
Minai „ . . .	228	113·761	0·08	28,990·4
			Mean =	29,002·3

No one would suppose from this table that the mean height could be over 100 feet in error, yet observations from the Darjeeling hills have yielded the following results :—

TABLE III.

Height of Mount Everest as observed from Darjeeling Hills.

Station of observation.	Year of observation.	Height of station of observation.	Distance from Mount Everest.	Coefficient of refraction.	The resulting height.
		Feet.	Miles.		Feet.
Suberkum H.S. . .	1881	11,641	87·636	0·05	29,141
Tiger Hill „ . .	1880	8,507	107·952	0·05	29,140
Suberkum „ . .	1883	11,641	87·636	0·05	29,137
Sandakphu „ . .	1883	11,929	89·666	0·05	29,142
Phallut . „ . .	1902	11,816	85·553	0·05	29,151
Senchal . „ . .	1902	8,599	108·703	0·05	29,134
				Mean =	29,141

If the coefficient 0·05 employed in Table III is too small, then the value of height 29,141 is too great. If 29,141 be accepted as the height of the mean snow level at the summit of Mount Everest, then a coefficient of 0·063 will be correct in Table II. From the plains of India a coefficient of 0·063 will give a value of 29,141.

I have calculated the heights of a number of peaks as obtained from each station of observation employing different refraction coefficients. The object of the calculation was to see which coefficient of refraction rendered the several values of height most accordant.

The following table shows the results for Nanga Parbat:—

TABLE IV.

Height of Nanga Parbat.

Station of observation.	Height of station of observation.	Distance from Nanga Parbat.	Height with refraction coefficient of						
			0·04	0·05	0·06	0·07	0·08	0·09	0·10
	Feet.	Miles.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
Ahartátopa H.S. .	13,029	133·744	26,929	26,689	26,449	26,210	25,970	25,734	25,494
Pahárgarh ,, . .	11,356	118·751	26,928	26,739	26,551	26,362	26,174	25,988	25,800
Gogipatri ,, . .	7,752	95·055	26,848	26,726	26,604	26,485	26,363	26,243	26,124
Harámukh ,, . .	16,001	59·275	26,694	26,647	26,599	26,552	26,505	26,460	26,413
Kájnág ,, . .	12,111	73·559	26,740	26,669	26,595	26,524	26,452	26,380	26,307
Poshkar ,, . .	8,323	83·491	26,843	26,749	26,654	26,562	26,468	26,376	26,282
Ismáil-di-dori ,, . .	12,630	63·805	26,727	26,671	26,617	26,563	26,508	26,454	26,400
Safápur ,, . .	10,296	66·339	26,681	26,624	26,564	26,506	26,447	26,387	26,329
Hánt ,, . .	13,479	43·167	26,671	26,646	26,621	26,596	26,572	26,546	26,522
Manganwár ,, . .	8,715	56·510	26,682	26,638	26,596	26,553	26,510	26,467	26,425
Márinág ,, . .	11,814	46·342	26,664	26,636	26,606	26,579	26,549	26,520	26,492
Mean =	...	...	26,764	26,676	26,587	26,499	26,411	26,323	26,235
Range of variation in values . .	...	...	265	125	205	386	602	812	1,028

It will be noticed that when a coefficient of 0·10 is used, the height of Nanga Parbat as determined from different places varies between 25,494 and 26,522 a range of 1,028 feet.

This great variation shows that the coefficient of 0·10 is inapplicable: with a coefficient of 0·09 the height varies from 25,734 to 26,546, a range of 812 feet. The range of variation decreases, until with a coefficient of 0·05 all the values of height fall between 26,624 and 26,749, a range of 125 feet. If we decrease the coefficient still further to 0·04, the variations again begin to increase, and the range extends 265 feet from 26,664 to 26,929.

The actual height adopted by Montgomerie for Nanga Parbat was 26,620, and we are unable to improve upon his value: it is produced if a general coefficient of 0·057 be accepted for refraction.

If we go through the same process with regard to Dhaulagiri, we get the following table* :—

TABLE V.

Height of Dhaulagiri.

Station of observation.	Height of station of observation.	Distance from Dhaulagiri.	Height with refraction coefficient of						
			0·04	0·05	0·06	0·07	0·08	0·09	0·10
	Feet.	Miles.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
Morairi T.S. . .	334	105·975	27,370	27,220	27,070	26,920	25,770	26,617	26,467
Bánarsi ,, . .	329	95·625	27,432	27,308	27,184	27,060	26,936	26,812	26,689
Sáunharsa ,, . .	315	104·043	27,509	27,363	27,217	27,071	26,925	26,779	26,634
Púrena ,, . .	299	105·800	27,411	27,261	27,111	26,961	26,811	26,661	26,511
Ghnos ,, . .	327	95·812	27,356	27,232	27,108	26,984	26,860	26,736	26,612
Tulsipur ,, . .	376	104·461	27,346	27,200	27,054	26,908	26,762	26,616	26,469
Anárkali ,, . .	434	137,340	27,624	27,370	27,116	26,862	26,608	26,354	26,100
Mean =	...	...	27,435	27,279	27,123	26,967	26,810	26,654	26,497
Range of the variation in values . .	...	...	278	170	163	209	328	458	589

* The results for Dhaulagiri cannot be discussed by this method so satisfactorily as those for Nanga Parbat. The effects of errors in refraction upon a given height only show themselves if the station has been observed from different distances. Nanga Parbat was observed from distances varying from 43 to 133 miles, and the adoption of a wrong value for refraction at once produces discordances. Dhaulagiri was observed from distances varying between 95 and 137 miles, and discordances are consequently less. If the distances of all observing stations had been equal, no discordance would have been produced however great the error of refraction.

The accepted height of Dhaulagiri is 26,795 feet, which was derived from a mean coefficient exceeding 0·08. A coefficient of 0·063 would have been nearer the truth, and in that case the height of Dhaulagiri would have been given at 27,076.

This method of tabulating values of height, derived from different coefficients, suffices to give an approximation to the true refraction, but it ought not to be trusted too far: refraction varies with temperature, pressure, haze, and humidity, and we have no right to assume, as this method does, that the same coefficient is applicable at every observing station.

The above examples serve to illustrate the present position of the problem of refraction; it is too early yet to make deductions from the experiments recently carried out near Dehra Dun. But the following results serve to indicate the desirability of continuing observations; the peaks of Kedarnath, Bandarpunch, Srikanta, and Jaonli were observed to be from 20 to 25 feet lower in March 1906 than in November 1905. Now this result is clearly fallacious. After the winter snowfall these peaks must have been higher than before: the conclusions are that refraction raises them in appearance more in November than in March, and that the apparent additional elevation of autumn is greater than the real additional elevation by winter snow.

On the Relative Movements of Land and Sea.—A tidal observatory was opened at Okha in the Gulf of Cutch in 1904, and closed in 1906. The Okha observations were required for the completion of a scheme that was commenced in 1874. A large area of Cutch is barely elevated at all above the mean level of the sea, and is frequently under water at high tide. Forty years ago it was believed that the coast of India was slowly subsiding with regard to the sea between Karachi and Bombay. To test the correctness of this view tidal observations were made in 1873 and 1874 at Okha, and the relative heights of land and sea were determined. After a lapse of 30 years the observatory at Okha was re-opened, and a fresh determination of mean sea level has now been made.

The tidal observatory was connected by spirit-levelling both in 1874 and 1906, with several bench marks situated at different distances from the coast, the most distant being 11 miles from the observatory.

The observations of 1904—1906 have shown that the land is higher

now with regard to mean sea level by 0·6 of an inch than it was in 1873—1875.

The results do not then support the theory of subsidence; they indicate an increase of elevation.

It would perhaps be safer to say that no relative movement of land and sea has been detected. For 31 years an uninterrupted series of tidal observations has been taken at Karachi, and the mean sea level has been annually determined. Though no evidence of a relative movement of land and sea has been found to be in progress, yet the determination of mean sea level from one whole year's observations has frequently differed from the general mean value of all the years by more than 0·6 inch. The mean level of the sea along a coast line is not only affected by tides, but by currents and winds, the influence of which varies slightly in different years. The sea level is dependent moreover upon the amount of ice accumulating in polar regions, and it responds also to movements of the earth's centre of gravity, and of the earth's rotation axis. These several causes of change prevent a final determination of mean sea level being deduced from the observations of any one year.

In 1902 the mean level of the sea for the whole year was higher than the average,—at Karachi by 1·44 inch at Bombay by 0·91 inch, at Aden by 1·72 inch; at Madras, however, it was lower than usual by 1·61 inch: in this year, then, though the mean level of the Arabian Sea was unduly high, a corresponding elevation was not observed in the Bay of Bengal.

In the following year, 1903, the mean sea level was too high throughout Indian waters,—at Aden by 1·37 inch, at Bombay by 1·00 inch, at Madras by 1·22 inch, at Rangoon by 0·41 inch, in the Andamans by 1·77 inch.

In 1891 both the Arabian Sea and the Bay of Bengal were low: the mean sea level at Aden was 0·14 inch below the average, that at Karachi was 1·27 inch too low, that at Bombay 0·96 inch too low, that at Calcutta 2·29, that at Rangoon 2·73, that at the Andamans 1·37—all too low.

The mean level of the water at riverain observatories is largely influenced by rainfall; the mean level of the Hooghly at Calcutta during the ten years from 1885 to 1894 was 6·8 inches higher than the mean level during the next ten years, 1895 to 1904. If this large and

persistent difference appeared at any open coast observatory, we should attribute it to an elevation of the land. At an open coast station if there has been neither elevation nor subsidence of land, the mean sea level derived from any *ten* consecutive years of results will not be found to differ from the general mean of all observations by more than 0·1 inch. A persistent difference of level of over half a foot at Calcutta between the two decades cannot, however, be regarded as evidence that the land at Calcutta is rising: it must be attributed to a diminution of water in the Hooghly.

On the Metallic Alloy "Invar" (Invariable).—At the request of the Surveyor General, Captain Turner, R.E., who is now on duty at Chatham, has been deputed to study the subject of invar. In 1895 the discovery was made that if nickel and steel be mixed in certain proportions the resultant alloy expands but little under the influence of heat. A minute expansion does take place, but it is less than that of any other alloy or metal.

If the temperature of a ten-foot bar be raised one degree centigrade, its expansion—

if of steel, is 0·0012 inch,
if of brass, is 0·0022 inch,
if of invar, is 0·00005 inch,

and specimens of invar have been known, the expansion of which was 0·00001 inch.

If nickel and steel are mixed in varying proportions, the expansion of a ten-foot bar will be as follows for one degree centigrade:—

Proportion in invar.		Expansion.
Of nickel.	Of steel.	
26 per cent.	74 per cent.	·0016 inch.
31 „ „	69 „ „	·0004 „
36 „ „	64 „ „	less than ·0001 „
43 „ „	57 „ „	·0008 „
48 „ „	52 „ „	·0012 „

The discovery of an alloy that does not expand with heat will be of great service to geodesy, and possibly to topography, for all linear measurements depend upon the lengths of standard bars.

The standard of length for India is a ten-foot wrought iron bar, which is kept at Dehra Dun: the tenth part of this bar at a temperature of 62·00 Fahrenheit is the Indian Survey standard foot. The standard of length for England is a three-foot bronze bar deposited in the office of the Exchequer in London.

In 1864 a comparison was made by Colonel Clarke between the English and Indian standards at Southampton. The Indian primary standard was not sent home: the comparisons were made against two secondary standards which were subsequently compared against the primary at Dehra Dun. The national standard yard of England was also not sent to Southampton for the comparisons, and Colonel Clarke had to assume that the yard was the mean length of five copies of the national standard, two of which belonged to the Ordnance Survey and three to Greenwich Observatory.

Colonel Clarke found that the Indian standard foot was shorter than the English foot by 0·0000521 inch.

On this account the length of the Indian arc of meridian from Cape Comorin to Dehra Dun has to be decreased by 33 feet, when it is utilised in conjunction with European arcs for determinations of the figure of the earth: similarly the Indian arcs of longitude have to be decreased proportionally when they are introduced into the problem.

When very refined measurements of length are being made, a chief source of error lies in the uncertainty that attaches to the temperature of the standard bar. We can determine the temperature of the air by thermometers, but the temperature of a solid bar differs from that of the air. If the temperature of the air were to remain unchanged for days, that of the bar would be equal to it: but when the air temperature is constantly varying, the bar temperature does not respond readily but lags behind. During the measurements of the Indian base-lines, the thermometers were inserted in holes in the bars, and in order to ensure perfect contact between the bulbs and bars, mercury or oil was poured into the holes. The precaution was also taken of making measurements when the air temperature was both falling and rising; in the morning when the air temperature is rising the bar temperature

is below it; in the afternoon when the air temperature is falling the bar temperature is above it.

But these precautions never sufficed to produce perfect confidence. The exact length of the measuring bar was never determinable. The discovery of "invar" has reduced the errors arising from uncertain expansion to one-thirtieth of what they were, and has enabled an accuracy to be attained in base-line measurements greater than our predecessors thought possible.

It seems probable that all base-line bars and wires and even standards of length will be made in future of invar. The base-lines of Burma will be measured with invar wires, and for their daily comparison an invar standard of length will be necessary. Whether the use of the invar standard will be confined to the field, or whether it will completely supersede the present iron standard, will depend upon further investigation: it is believed that invar bars slowly increase in length in the course of years, and if this proves to be the case, they can never be adopted as permanent national standards.

Great precautions have been taken in the past to save astronomical clocks from exposure to variations of temperature.

In European observatories the clocks are in underground cellars, and during the Indian longitude observations they are enclosed in grass huts. The rate of a clock varies with the length of its pendulum, and no reliable rate can be obtained if the pendulum is not protected from variations of temperature. Of recent years pendulums of clocks have been made of invar, and variations of temperature are consequently no longer to be dreaded to the same extent.

A pendulum is not only used for the regulation of clocks, but also for the measurement of the intensity of gravity. The force of gravity can be determined from the number of swings that a pendulum of known length makes in a day. But if the pendulum has varied in length, the observations are useless; if it has lengthened from heat, it will swing more slowly, and gravity will be given too small; if it has contracted, its oscillation will be too rapid, and gravity be shown too large. In the last four years Major Lenox-Conyngham has had great difficulties, firstly, in maintaining the temperature constant; secondly, in determining the lag of the temperature of the pendulum behind that of the air. In 1905, seeing the improvement which the introduction of invar

had made in pendulum clocks, Major Lenox-Conyngham proposed to construct an invar pendulum for gravitational measurements. He consulted the Director of the National Physical Laboratory at Teddington, who informs him that invar is sufficiently magnetic to be an undesirable material for gravitational pendulums. A clock pendulum is required only to give a constant rate, and the fact that it is composed of magnetic material does not interfere with constancy. But a gravitational pendulum is required to give the absolute and particular rate which local gravity produces, and if it is swinging under the combined influence of the earth's magnetism and gravity, an excessive rate will necessarily be developed.*

Pendulum Operations in the Punjab and Baluchistan.—During the field season of 1905-06 Major Lenox-Conyngham observed the pendulum at several stations in the Punjab and Baluchistan.

Former pendulum observations taken south of Darjeeling and Mussooree had brought to light three facts, *viz.* :—

(i) Under the outer Himalayan ranges the crust of the earth is deficient in density,—the deficiency amounting in the aggregate to some 3,000 feet of rock.

(ii) Along the flat zone, which encircles the outer Himalayan ranges on the south, and which forms the northern edge of the Gangetic plains, the crust of the earth is deficient in density to the same extent as under the ranges.

(iii) The deficiency in the earth's crust becomes gradually less as we move southwards from the mountains across the plains, until another zone is reached, parallel to the Himalaya, and 200 miles distant, throughout which the earth's crust possesses an excessive density.

In North-Eastern India there are therefore three variations in the crust, where the eye-observer notices but two forms of surface. The eye-observer sees a mountainous region on the north, and flat plains to the south; the pendulum observer finds three parallel zones,—the zone of mountains on the north, the zone of deficiency in the centre, the zone of excess to the south.

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* M. Lippmann calculates that if the vertical magnetic force be 0·3 C. G. S., the value of "g" will be given too large by 0·002. *Comptes Rendus de l' Academie des Sciences, 1904.*

In 1905-06 Major Lenox-Conyngham took pendulum observations across the plains of the Punjab from the outer Himalaya to the Baluch mountains. The following table illustrates his results :—

Pendulum station.	Region.	Excess or deficiency in the observed force of gravity.	Visible excess of rock above sea level = height of station = H.	Invisible excess or deficiency of rock as revealed by the pendulum = D.	Resultant excess or deficiency of rock, *i.e.*, the height above sea level, if crust were reduced to normal density = H−D.
		Centimetres.	Feet.	Feet.	Feet.
Simla . .	Outer Himalaya .	−0·119	+ 7,043	− 3,380	+ 3,663
Kalka . .	Foot of the Himalaya.	− 0·084	+ 2,202	− 2,386	− 184
Pathankot .	Ditto .	− 0·178	+ 1,088	− 5,055	− 3,967
Ludhiana .	Eastern Punjab plains.	− 0·046	+ 833	− 1,306	− 473
Mian Mir .	Central Punjab plains.	+ 0·006	+ 708	+ 171	+ 679
Ferozepore .	Ditto .	+ 0·008	+ 647	+ 228	+ 875
Montgomery .	Ditto .	+ 0·005	+ 557	+ 143	+ 700
Multan . .	Western Punjab plains.	− 0·043	+ 404	− 1,226	− 822
Dera Ghazi Khan.	Near foot of Baluch mountains.	− 0·086	+ 397	− 2,442	− 2,045
Quetta . .	In the Baluch mountains.	− 0·138	+ 5,520	− 3,919	+ 1,601

The fourth column gives the height of the station in feet, and this represents the excess of matter in the crust, standing above sea level and visible to us. The fifth column gives that amount of matter in the crust, which is in hidden excess or defect of the visible amount, and the numbers in this column are derived from the pendulum observations. The last column shows the height above sea level at which the several stations would be situated, if the crust of the earth were everywhere made homogeneous and brought to normal density.

Simla overlies large deficiencies of density, and when these are allowed for, its actual excess of mass above sea level is reduced to 3,663 feet of rock. The hidden deficiency underlying Kalka slightly exceeds the visible excess above sea level, so that on a homogeneous crust Kalka would stand 184 feet below sea level.

The deficiency at Pathankot is extraordinary: this station is situated only 1,088 feet above the sea, and yet a deficiency of mass underlies it equivalent to 5,055 feet of rock: on a homogeneous crust Pathankot would be situated 3,967 feet below sea level.

The results of the above table resemble those obtained in Bengal and Rohilkhand. Under the mountains of the Punjab and under the flat plains at their foot, the earth's crust is deficient in density (see column V): under the plains that are distant from the mountains the density of the earth's crust exceeds the normal (see column V).

In 1885 the direction of gravity on the Eastern Punjab plains at Amritsar was found to be deflected away from the visible Himalaya towards the flat plains: in the same year the direction of gravity on the Western Punjab plains at Multan was observed to be deflected away from the visible Baluch mountains towards the plains. It was then held that deficiencies of density were underlying both ranges of mountains, sufficiently large to over-compensate the visible mountains themselves, and to deflect plumb-lines away from them. But this explanation was erroneous. The mountains are not over-compensated: the visible height of rock at Simla is 7,043 feet, the hidden and compensating deficiency is only 3,380 feet, and consequently there is in the earth's crust at this point of the Himalaya a resultant excess of mass equivalent to 3,663 feet.

Similarly at Quetta, although there is a compensating subterranean deficiency of 3,919 feet, yet Quetta stands 5,520 feet above sea level, and the resultant excess of mass is 1,601 feet. It is not possible, therefore, to maintain that plumb-lines in the Eastern and Western Punjab are deflected away from the mountains by the subterranean deficiencies of the latter.

The pendulum observations furnish a simple explanation of the deflections: across the centre of the flat plains of the Punjab from north to south runs a zone of excessive density, which may perhaps be described as a buried chain of mountains; Mian Mir, Ferozepore, and Montgomery are situated on the broad crest of the chain. On

the edges of the Punjab plains, east and west of the buried chain, are deep invisible troughs, which separate it from the Himalaya and Baluch mountains respectively: the floor of the eastern trough at Pathankot would on a homogeneous crust be 4,842 feet below the summit of the chain at Ferozepore, though it now stands 441 feet above it: the floor of the western trough at Dera Ghazi Khan would be 2,745 feet below the crest of the chain at Montgomery, though it now stands 160 feet below it.

The plumb-line station of Amritsar stands in the trough between the buried chain and the Himalaya, and nearer to the former than to the latter; the plumb-line station of Multan stands in the trough between the buried chain and the Baluch mountains, also nearer to the former than to the latter. At each place the attraction of the buried chain on the plumb-line is greater than the attraction of the visible mountains.

In addition to the stations included in the above table, Major Lenox-Conyngham took observations at three stations south of Quetta with the following results:—

Pendulum station.	Region.	Excess or deficiency in the observed force of gravity.	Visible excess of rock above sea level = height of station = H.	Invisible excess or deficiency of rocks as revealed by the pendulum = D.	Resultant excess or deficiency of rock, *i.e.*, the height above sea level, if crust were reduced to normal density = H. D.
		Centimetres.	Feet.	Feet.	Feet.
Quetta	In the Baluch mountains.	—0·138	+5,520	—3,919	+1,601
Mach	Ditto.	—0·115	+3,522	—3,266	+256
Sibi	At the foot of the mountains.	—0·116	+434	—3,294	—2,860
Jacobabad	In the plains distant from the mountains.	+0·033	+183	+941	+1,124

Here we note the same phenomena. The Baluch mountains, like the Himalaya, are partially compensated by underlying deficiencies, but not to the full extent of their visible height: Sibi, like the other sub-montane stations Pathankot, Dehra Dun, and Siliguri, has a large deficiency of matter in the crust. At Jacobabad, 100 miles south of Sibi, gravity is in strong excess. Between Sibi and Jacobabad are flat plains, declining 251 feet in height; yet the pendulum shows that if the crust of the earth was homogeneous, Jacobabad would stand 3,984 feet higher than Sibi. It is not hazardous to predict that the plumb-line between Sibi and Jacobabad, when it comes in the future to be observed, will be found deflected away from the visible Baluch mountains and towards the mass that lies hidden under Jacobabad.

It is interesting to have discovered that the same alternation from deficiency to excess as has been found to exist under the plains of Bengal occurs under the plains surrounding the Baluch mountains. It is probably due in both cases to the weight of mountains pressing on the yielding crust of the earth, and it shows how the crust can be compressed into a long line of subterranean density without being crumpled into a fold at the surface. These considerations lead us to hope that the numerical results of pendulum observations may prove valuable data for investigations of the crust's rigidity and elasticity.

As far as we can judge at present from plumb-line observations only, there is no zone of crustal deficiency surrounding the Vindhya; before, however, conclusions can be drawn, it will be necessary to observe the pendulum on these mountains. The Vindhya belong to an older geological period than either the Himalaya or the Baluch mountains, and, unlike the two last named, are not folds of the earth's crust.

If we had been dealing with pendulum observations only, we should not now be able to decide whether the observed variations in crustal density were superficial or deep-seated; but the fact that the plumb-lines at Amritsar and Multan are deflected away from visible mountains towards the buried chain proves that the latter must be exercising a powerful horizontal attraction at the earth's surface, and cannot consequently be deep-seated. It is unlikely, however, that the chain of density approaches actually to the surface, or the latter would obtain relief from pressure by wrinkling.

GEOGRAPHY.

BY

LIEUT.-COLONEL S. G. BURRARD, R.E., F.R.S.,
Superintendent, Trigonometrical Surveys.

Seistan.—During the last thirty years our knowledge of Afghan geography has steadily increased; the blank spaces in maps have been growing smaller, the scale of mapping has been gradually enlarged; the detail represented has been made more complete; and the Great Triangulation of India has been slowly advancing beyond the Indus, and unifying fragmentary surveys in its progress. Nevertheless even now there are but small portions of Afghanistan of which it can be said that *topographical* maps exist.

During the long sojourn of the Seistan Mission in Afghanistan, Mr. G. P. Tate of the Survey of India, who had had much previous experience in Afghanistan and Baluchistan, carried out a topographical survey of 42,000 square miles on the scale of 4 miles = 1 inch: 3,000 square miles were surveyed on the scale of 1 mile = 1 inch. Mr. Tate is now preparing his maps and memoir: the latter will contain accounts of the ancient and the present topography of Seistan, of its archæology and ethnology.

In order to understand the geography of Seistan it is necessary to study the river Helmand. The sources of the Helmand are on the southern slopes of the Hindu Kush. North of Chitral, the Hindu Kush range expands into the gigantic pyramid of Tirich Mir (25,426 feet), but west of Tirich Mir it carries no peaks of 20,000 feet. Tirich Mir is in the basin of the Indus, and the Helmand drains only the low western portion of the range.

With the exception of the Indus no one of the rivers that issue from the west or north of the Tibet mountain system succeeds in reaching the sea: the Oxus and the Jaxartes empty their waters into a shallow depression of Western Asia and create the sea of Aral; the rivers of Yarkand and Tarim flow into an easterly depression and make the lagoons of Lob Nor. The Helmand takes a south-westerly course

through Afghanistan, but is stopped by a small range of hills near the Persian border.*

The water brought down by the Helmand runs to the lowest part of the region and forms the lagoon of Seistan: the country of Seistan is the delta formed by the Helmand in the lake, which it has also formed. The delta is an oasis of Central Asia and supports a population of 105,000. Mr. Tate found that the Seistan lagoon was nowhere deeper than 10 feet: he estimates its area to be 2,000 square miles. In the arid climate of Central Asia a quarter of an inch depth of water will be evaporated daily from an exposed surface, and we can thus realise how rapidly the Seistan lagoon would become dry if the supplies from the Helmand ceased.

If the Seistan lagoon resembles other inland seas and lakes, it must be becoming shallower: the silt brought down by the river must be filling up the depression, and as the depth of the water decreases, the surface exposed to the attacks of evaporation must be growing larger.

Some authorities have held that the silt brought down by the Helmand is removed by wind, and that the Seistan basin is not being filled up. But the water of Seistan, like that of Lob Nor, is known to have oscillated in the past between different portions of the basin, sometimes occupying one, sometimes another; and such oscillations are primarily the results of silting up. I do not think that any complete proof has been furnished that the Seistan lagoon is being saved by wind from the fate that overtakes all such lakes.

The observations in Seistan may be expected to throw light upon the great problem of the desiccation of Asia. That Central Asia has suffered from desiccation all observers are agreed, though they have differed as to the cause. That land was once cultivated, which is now desert,—that towns once existed where there are now but ruins,—that large populations once dwelt in regions that are now devoid of life,—these are facts which may be accepted as established.

It has been held by some authorities that the disappearance of cultivation and towns and population is due to misgovernment, wars, and pestilence: others have argued, and among these is Mr. Pumpelly, who has recently led a scientific expedition through Central Asia, that wars

* Height above sea level of the surface water in the—

Sea of Aral	158 feet.
Lob Nor	2,600 „
Seistan lagoon	1,640 „

and misgovernment are insufficient to account for the phenomena, and that permanent climatic change is the only adequate cause.

The theory that a permanent climatic change has occurred within the human period cannot, I think, be accepted without meteorological proof. Observations of the Nile have been carried out for centuries, and no evidence of climatic change has been discovered. In the valleys of the Euphrates and Tigris popluation has decreased since the days of Babylon, and in these cases the decrease may certainly be attributed to misgovernment. There are indications in Baluchistan that a former population used to catch and store the flood water of storms, which now all runs to waste.

In rainless seasons the populations of deserts are always compelled to migrate, and if they find elsewhere a settled country where they are allowed to live in peace, it is possible that they may fail to return to their homes in the sand—in which case the *relative* merits of neighbouring governments become factors that cannot be excluded from the problem.

Before, however, any definite conclusions upon the problem of desiccation can be formed—and before we can ascertain whether that desiccation is still continuing or not—it will be necessary to study the accumulations and movements of sand. Although much has been written on these subjects, nothing definite is known as to the rate at which sand accumulates, nor as to the rate at which it moves in mass. Can the observed decreases of population in Asia be due not to diminishing rivers, but to increasing or advancing sand?

The surface rocks of the great protuberance of Tibet are everywhere decomposing, and the several rivers that have their sources in Tibetan glaciers carry down immense loads of silt and sand. The sand is borne by the Indus and the Ganges to the ocean, but by the Oxus and Helmand and Tarim rivers it is deposited in the inland depressions of Asia. The annual additions of sand to the deltas and deserts of Asia are always increasing the amounts already accumulated in past centuries. Even if wind does scour out the Seistan basin, the sand removed is not carried far.

Whilst, however, the sand never ceases to increase, the water in the rivers remains constant. A certain volume of water is required to keep down accumulations of sand; when the water supplied is in excess of the requisite amount, as in the valley of the Ganges, sand hills do not

appear; but when the water is in defect, the sand accumulates and chokes rivers. The Tarim basin, enclosed as it is by disintegrating mountains, is becoming choked with sand; almost all its rivers that have their rise in the Kuen Lun range end now in its deserts and fail to reach Lob Nor.

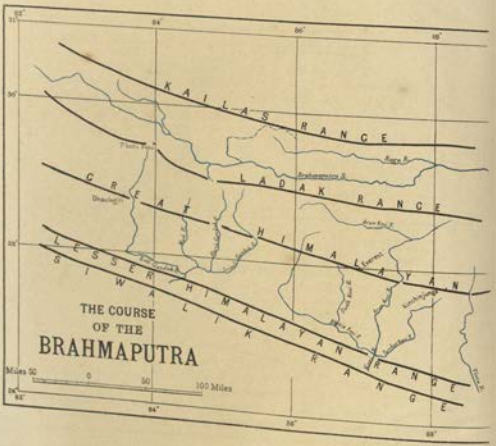
Even in India, where the rainfall is so much greater than in Central Asia, we can see the effect of sand upon rivers; under the influence of the south westerly wind the sand of Rajputana is advancing towards Umballa and Simla; though it has been kept in check by the rainfall at the foot of the Himalaya, it has succeeded in choking and stopping the Ghaggar: it has forced the Sutlej to bend to the north; it has driven the Jumna to the east; and its opposition has compelled the Punjab rivers to unite in order to reach the sea. That the sand of Rajputana is advancing I take to be proved: but the rate at which it advances is unknown.

The lagoons of Seistan and Lob Nor are examples of the victory of water over sand: but even in these cases it is under present conditions only a question of time, when the Helmand and the Tarim will be stopped like the Ghaggar, and their lagoons will have disappeared. The sand is always increasing, whilst the water is not.*

On the Exploration of the Brahmaputra.—The most curious feature of the Brahmaputra in Tibet is the tendency of all its principal tributaries to flow in a direction opposed to that of the main stream (*vide* accompanying chart); the probable explanation of the phenomenon is that the Brahmaputra itself flowed from east to west along its present trough at no very distant date, and that the several tributaries were developed during that period of the river's history.

In longitude 94° the Brahmaputra bends and forces a passage through the Himalayan ranges to Assam: the fact that it has only recently begun to flow from west to east renders the problem of its passage across the mountains one of great interest. A century ago it was believed that the deep gorges through which rivers cross mountain ranges were the results always of fractures or fissures: but geologists have so often found this view to be erroneous, that it can no longer be

* Since this report was submitted, a paper by Sir Henry McMahon has been published in the Geographical Journal' for September 1906. Sir Henry is of opinion that the Seistan basin is gradually subsiding from the weight of the silt deposited on it, and that it is not in consequence becoming choked.


KAILAS RANGE
LADAK RANGE
GREAT HIMALAYAN
LESSER HIMALAYAN
SIWALIK RANGE
THE COURSE
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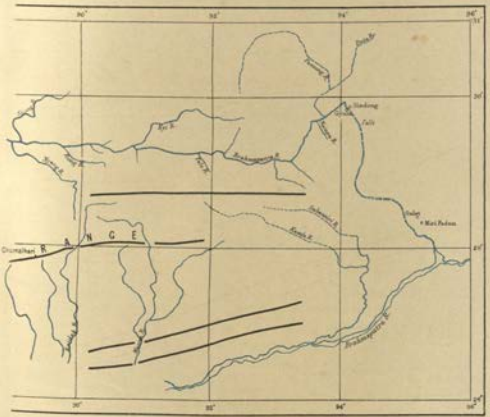
RANGE

advanced without proof. The gorges of the Brahmaputra through the several mountain ranges have been in all probability carved by water, and the problem is, how have they been so carved?

There is no ground for believing that the Brahmaputra river is older than the Himalayan mountains, or that it has maintained an ancient course across them as they slowly rose.

It is, moreover, difficult to accept the theory that the river has gradually cut back from the south into the ranges by head-erosion.

The explanation that seems least objectionable is that the Brahmaputra when it reversed its course formed a great lake in South-Eastern Tibet, which overflowed over the southern ranges and gradually cut a gorge across them. This is what we now see happening in Kashmir, where the Jhelum is carving a gorge; the drainage of the Kashmir basin has but one outlet and overflows at the lowest notch in the rim of the basin. At the point of overflow a deep chasm is being cut in the Pir Punjal range.

The position of the lowest notch may be in the first instance determined by the action of local glaciers, but the Himalayan gorges themselves are due to volumes of water pouring through from behind, and deepening the channels before local drainage has time to modify the perpendicularity of the walls.

When a river cuts back by head-erosion into a range it creates a wide basin in which the lateral tributaries are duly developed; the only Himalayan river of the first magnitude in which lateral development has kept pace with that of the main stream is the Tista. Rivers like the Sutlej, the Kali-Gandak, and the Bhotia Kosi pass through the Himalayan ranges in narrow deep gorges, and such gorges can only be cut by water, if the water is gathered before it cuts.

The attached chart of the Brahmaputra contains interesting illustrations of the effect of young mountain ranges rising across the paths of older rivers; the three Gandak rivers and the three Kosi rivers were all flowing down from the Great Himalayan range before the lesser range began to rise. As the lesser range grew across their courses, it dammed five of the six rivers; the Arun alone possessed sufficient volume and force of water to keep its passage open; we can see this from the way that five of the rivers were severely deflected by the growth of the dam, whilst the Arun maintained its original course.

The same phenomenon is witnessed in places in the case of the Siwalik. When the Siwalik range rose it was able to dam and deflect a small stream like the Ramganga of Kumaon, but the Ganges maintained its course across it.

An interesting phenomenon of Himalayan geography is the repeated presence of the highest point of a range in close proximity to the deep gorge of a great river. Nanga Parbat, the highest point of the Punjab Himalaya, is 14 miles from the gorge through which the Indus passes the range; Rakhipushi, the highest point of the Kailas range, is within nine miles of the gorge of the Hunza river; Dhaulagiri is six miles from the Kali-Gandak. In escaping from Tibet the Sutlej appears to aim for the peak of Leo-Porgial, the highest point of the barrier range.

Without geological evidence it is not possible to come to any definite conclusion as to the cause of this repeated proximity: from observations of surface forms I have been led to think that the maximum elevations of a range tend to occur at places where the range bends, and that bends are at the same time the weakest parts of a range—the parts that are most easily attacked by water and ice.

It will be of interest to see if the Brahmaputra in piercing the Great Himalayan range has attacked it near a point of maximum elevation.

It will be noticed on the chart that in longitude 93° the Brahmaputra in Tibet bends to the north-east; this bend is repeated in the outer Himalayan ranges north of Assam; the bend of the river is probably, therefore, but a consequence of a sudden change in the alignment of the great range.

When a range changes its direction, it generally alters in form also, and the course and dimensions of the great range east of the Brahmaputra have yet to be determined. In the North-West Himalaya the great range at passing the Indus bends and rapidly declines in height. On the east the geography is uncertain; we have no data upon which to form an opinion as to whether the Himalayan range continues its course across the Salween and Mekong as has been maintained by Kropotkin, or whether it bends round into Burma, or whether it subsides and ends.

Somaliland.—Somaliland is the name given to the trigon of land which protrudes from East Africa into the Arabian Sea: the granite

island of Socotra is a solitary fragment of an ancient extension of the African Continent. In modern times the eastern extremity of Somaliland and of Africa is Cape Guardafui.

In former geological ages Somaliland formed part of a great plateau, which included North Africa and Arabia. The subsidence of a long zone of this plateau is believed by Suess to have been the origin of the Red Sea; a further subsidence of the area between Somaliland and Arabia created the Gulf of Aden.

In 1903, Captain Beazeley, R.E., Survey of India, accompanied the Somaliland Expedition and succeeded in surveying 15,000 square miles of the country on the scale of 4 miles=1 inch. He describes the region as one vast bed of limestone several thousand feet in thickness: the surface rises at an uniform slope of 10 feet a mile from the south-east coast line and attains an elevation of 3,000 feet, when it abuts against the mountains of Abyssinia. Somaliland is thus a tilted plateau.

The northern and western mountains of Abyssinia contain the sources of the Nile; the drainage of its south-eastern highlands is across Somaliland. Captain Beazeley found that all the rivers of Somaliland, which have their rise in Abyssinia, disappear before they reach the sea. The Webbe Shebeli has a considerable volume of water derived from the Abyssinian snows, and it maintains its course in Somaliland for upwards of 700 miles; but it eventually loses itself in sandy soil 20 miles before reaching the coast.

There is a very marked underground system of drainage, which supplies wells all over the country. An impermeable stratum appears to exist 60 or 70 feet below the ground surface, and when wells are deepened below this, their water disappears. The Der river has a distinct bed for 150 miles, but it then vanishes in marshy ground: after remaining hidden for 100 miles it re-appears at the surface, and flows to the sea under the name of the Dun.

Somaliland was formerly occupied by a people called Gallas, who irrigated and cultivated the ground. The present inhabitants are Somali nomads, who expelled the Gallas; they make no attempt to cultivate, and all signs of the former Gallas civilisation are rapidly dying out. Captain Beazeley is of opinion that the decadence of the country is not due to a failing or diminishing rainfall, but to the presence of the Somalis.

BOTANICAL SURVEY.

BY

CAPTAIN A. T. GAGE, I.M.S., M.A., B.Sc., M.B., F.L.S.,
Director, Botanical Survey of India.

Eastern India.—BENGAL.—In Chota Nagpur the Rev. Father Cardon, S.J., continued to lend his aid in collecting living tubers of selected monocotyledonous orders, for cultivation in the Royal Botanic Garden, Calcutta, and subsequent identification there. Although no new species have been discovered—such discoveries being rather unlikely now—Father Cardon's collections are valuable in extending our knowledge of the geographical distribution of Indian species. About the beginning of the year a native collector was sent to Orissa, which is still to a considerable extent botanically a *terra incognita*, and the resulting collections are likely to prove of considerable interest from a phyto-geographical point of view. Another native collector was sent to Tirhut to collect the wild flora on the Government Estate at Pusa ere it disappears before the extension of agricultural operations there. In the Chumbi Valley further collections were made by one of the garden collectors who accompanied Mr. J. C. White, C.I.E. Mr. G. H. Cave, the Curator of the Lloyd Botanic Garden, Darjeeling, made during July 1906 an interesting botanical excursion into Central Sikkim, his route being from Gangtok to Talung, thence to Eumtso La, back again to Talung and thence to Lachen, and from Lachen by the military road to Tista Bridge. The interest of Mr. Cave's collections is increased by the itinerary notes which accompany it. The writer, while on his visits of inspection to the Cinchona Plantation in the Darjeeling District, made a collection of the local plants with a view to supplement the Herbarium in the Lloyd Botanic Garden in Darjeeling.

ASSAM.—In this province a long tour was made on behalf of the Botanical Survey by Mr. A. Meebold, a German gentleman and an enthusiastic botanist, who had been working out in the Herbarium of the Calcutta Botanic Garden during the cold weather of 1905-06 the results of his collections in other parts of India. In Assam he followed the route which had previously been traversed by Dr.—now Sir George—Watt, Reporter on Economic Products to the Government of

India in 1882, and by the late Mr. C. B. Clarke, F.R.S. The route lay up the Brahmaputra Valley to Gauhati, thence across to Kohima, then from Kohima to Manipur, and from Manipur to Silchar. The time of the year was not the best possible, but despite that fact Mr. Meebold succeeded in bringing back quite an excellent collection.

BURMA.—A native collector was sent to the District of Pakokku, which is supposed to show even more pronouncedly than the District of Minbu to the south of it a xerophilous vegetation. Unfortunately both the plant collector and his works failed to commend themselves to the natives of the district, who showed their disapproval in a manner that could not be ignored, with the result that the collector had to be recalled. The survey, however, was benefited by the efforts of certain officers of the Forest Department in Burma. Mr. J. H. Lace, now of the Imperial Forest Research Institute, while Conservator of the Pegu Forest Circle, contributed to the Calcutta Herbarium a collection of excellently selected and prepared specimens, some of which are of considerable economic importance. The Conservator of the Tenasserim Forest Circle has sent a number of particularly interesting plants from that region, the vegetation of which is still very imperfectly known. The bulk of the collections from the Tenasserim Forest Circle has still to be worked up, but as it is, several interesting new species have been discovered, some of which have been described and published by the writer. In the Andaman and Nicobar Islands Mr. A. R. Brown, of Trinity College, Cambridge, who has been sent out under the auspices of the Royal Society primarily for anthropological research, has been and is collecting, as opportunity allows on behalf of the Botanical Survey. The Deputy Conservator of Forests has also sent an interesting set of specimens from the Andamans.

Western India.—Mr. G. A. Gammie, F.L S., Economic Botanist to the Government of Bombay and in charge of Botanical Survey Operations in Western India, made collections in Bassein, Ahmedabad, Kaira, Surat, Khandesh, Ahmednagar, Poona, Belgaum, and Dharwar. Mr. G. M. Ryan, of the Forest Department, has also collected during the year in the Thana and Poona Districts, and the results of his labours in the former district are now being elaborated by him in conjunction with Mr. Gammie. Mr. W. A. Talbot, also of the Forest Department, has, as usual, continued to do a good deal of botanical work on the western side of India, more especially

with regard to forest vegetation, which is treated of in another part of this report.

Southern India.—Mr. C. A. Barber, M.A., F.L.S., Government Botanist, Madras, collected the Balsams (*Impatiens*) of the Peninsula on behalf of Sir Joseph Hooker. Some ten new species of this perplexing genus have been discovered in South India alone. Mr. Barber has also paid particular attention to the peppers of the Presidency and has made a special study of the root parasites of Madras and their hosts, working on the genera *Santalum*, *Osyris*, *Thesium*, *Olax*, *Cansjera*, and *Ximenia*. A special expedition was made to the Travancore hills for the collection of *Ochlandra travancorica* to show the various stages of germination, of which a very fine series was obtained for Dr. Stapf, of the Royal Botanic Gardens, Kew.

Mr. C. E. C. Fischer, Deputy Conservator of Forests, Coimbatore, has made a very complete and very excellent collection of the flora of that district, a set of which he has kindly presented to the Calcutta Herbarium.

Northern India.—Mr. Meebold, the same botanist who toured in Assam on behalf of the Botanical Survey, also made a large collection of Kashmir plants, the bulk of which are being worked up at Breslau, where several new species have been discovered in the collection. The Hon. Mr. J. McC. Douie, I.C.S., has contributed several very interesting specimens to the Calcutta Herbarium, one of them being *Herminium gramineum* Lindl. found in Simla, a discovery which extends the range of that species quite in accordance with the anticipation of Mr. J. F. Duthie, F.L.S., late Director of the Botanical Department of Northern India, who had stated that it probably would be found there.

General.—The mere collecting of specimens in the various parts of India does not, however, comprise all the work of botanical research in India during the past year. Amongst other things the classification of the Indian *Gentianaceæ* has been revised by Mr. I. H. Burkill, Reporter on Economic Products to the Government of India, and the first fruits of his study have appeared as several papers in the Journal of the Asiatic Society of Bengal. The Calcutta Herbarium material of the Urticaceous genera *Ulmus*, *Holoptelea*, *Celtis*, *Trema*, and *Gironniera* have been under study at the

Botanical Institute of Buitenzorg in the Dutch Indies. So the Indian material of the large natural order *Araceæ* has been lent for study to Professor Engler, the distinguished Director of the Botanic Garden of Berlin, who visited the chief Botanical Institutions of India early in the year. Many of the drawings of plants of this order in the Calcutta Herbarium were copied for Berlin. Material of the natural order *Styraceæ* was also lent to Berlin for monographic purposes. To Sir Joseph Hooker, G.C.S.I., who has had under study for some time the difficult genus *Impatiens*, new material of the Indian Balsams contributed by Mr. Barber, Mr. Burkill, and others from various parts of India has been sent. Material for a comparative study of the African and Indian forms of *Borassus* palms has been supplied to Signor Beccari, of Florence, from the Calcutta Botanic Garden.

Since the days of the illustrious Griffith but little attention until lately has been given in India to the morphological, anatomical, and physiological sides of the Science of Botany. During the past year, however, a certain amount of work has been done on these lines. In India Mr. Barber's researches into the morphology and histology of root parasites are noteworthy. Outside India, Professor Carl Mez, of Halle a/S has been supplied with material for a study of variation in the opium poppy, and the Pflanzenphysiologisches Institut of Munich with material for a study of cleistogamous flowers. In vegetable physiology a great deal of work has been done by Professor J. C. Bose, M.A., Sc.D., C.I.E., of the Presidency College, Calcutta, whose work is further referred to under Publications.

Publications.—During the year two numbers, 2 and 3, of Vol. IV of the Records of the Botanical Survey of India have appeared, constituting the continuation and completion of Sir Joseph Hooker's "Epitome of the British Indian Species of Impatiens." Another number devoted to descriptions of new Eastern Asiatic species of the order *Sapindaceæ* by Professor Radlkofer, of Munich, is in the Press. Press difficulties have permitted the issue only of Part II of Vol. X of the Annals of the Royal Botanic Garden, Calcutta, which consists of a Monograph of the Aconites of India by Dr. O. Stapf of the Kew Herbarium. This monograph, which is illustrated with twenty-five plates, gives a history of the Indian Aconites, an account of the structure

of the roots, a systematic description of the species, a bibliography, and a list of vernacular names. There has also appeared as part of the same publication "A Sketch of the Life of Francis Hamilton (once Buchanan), sometime Superintendent of the Honourable Company's Botanic Garden, Calcutta," by Lieut.-Colonel Prain, formerly Superintendent of the Royal Botanic Garden, Calcutta, and now Director of the Royal Botanic Gardens, Kew. The sketch, which extends to 75 pages, is the fullest account that has yet been written of the extraordinary man whom it commemorates, and its interest is much more than merely botanical.

Of the Annals of the Calcutta Botanic Garden there have been for a very long time, and still remain in the Press, "A Monograph of the Orchids of the N.-W. Himalaya" by J. F. Duthie, B.A., F.L.S., formerly Director of the Botanical Department of Northern India; "Descriptions of new species of Algæ from Burma" by W. West and Professor G. S. West; and a magnificently illustrated monograph of the genus *Calamus* of climbing palms by Signor Beccari of Florence. It is to be hoped that by next year the Press will have rendered it possible to refer to some, if not all, of these as having appeared. Part 2 of Vol. II of Dr. Theodore Cooke's, "Flora of the Presidency of Bombay," comprising a description of the plants of the Presidency belonging to the natural orders *Boraginaceæ* to *Verbenaceæ*, has appeared. During the year a further instalment of the "Flora of the Upper Gangetic Plain" by Mr. J. F. Duthie, B.A., F.L.S., was sent to the Press.

Nos. 16, 17, and 18 of the materials for the, "Flora of the Malayan Peninsula," by Sir George King and Mr. Gamble, has appeared in the Journal of the Asiatic Society of Bengal. Those numbers comprise descriptions of the species belonging to the natural orders from *Rubiaceæ* to *Pedalineæ* inclusive.

The above-named works constitute the chief contributions to systematic botany. Mr. I. H. Burkill, as already mentioned, has published several papers on *Gentianaceæ*. Mr. G. A. Gammie, Economic Botanist to the Government of Bombay, has continued to describe the orchids of the Bombay Presidency in the Journal of the Bombay Natural History Society.

The writer has published several short papers descriptive of new species, and has also contributed a sketch of the herbaceous vegetation

of Burma to Sir George Scott's forthcoming Hand-book to that country. On the morphological and anatomical sides of Botany Mr. Barber's papers on root parasitism contributed to the Memoirs of the Department of Agriculture in India are the most important. In Plant Physiology the most noteworthy work of the year, as far as India is concerned, is the book by Professor J. C. Bose, M.A., Sc.D., C.I.E., of the Calcutta Presidency College, entitled "Plant Response as a means of Physiological Investigation," a work of 781 pages with 278 figures. This work has created very considerable interest amongst plant physiologists. To quote an American reviewer, the book "shows a method of attack and a refinement of instrumentation for the study of the phenomena of irritable reactions in plants that are sure to be of the utmost service." ..... The fundamental thesis of the book is that the underlying response to stimuli is alike in plants and animals, is alike in all plants and in all parts, with all stimuli, and is universal."

The following list comprises most of the books and papers bearing on the Botany of India, which have appeared during the period under review.

A list of papers bearing on the Botany of India published during 1905-06.

ARMOUR, HELEN M. . On the Morphology of Chloranthus (*New Phytologist*, v, No. 3, 1906, pp. 49—55, with 2 plates.)

BARBER, C. A. . . The Haustoria of Sandal roots. *Indian Forester*, xxxi, No. 4, p. 189, with 5 plates.

BARBER, C. A. . . The Haustorium of Santalum album. *Memoirs of Dept. of Agri. in India*, Bot. Ser., i, No. 2, with 7 plates.

BIRBAL, BABU . . The Ripening of Cones of Pinus longifolia. The formation of Pseudo-cones or Galls. *Indian Forester*, xxxi, No. 8, p. 425.

BLATTER, E. . . . The Mangrove of the Bombay Presidency, and its Biology. *Journ. Bombay Nat. Hist. Soc.*, xvi, No. 4, p. 644, with 2 plates.

BLATTER, E. . . . The " Pectinate organs " of Trapa bispinosa *Roxb.*—*Journ. Bombay Nat. Hist. Soc.* xvii, No. 1, p. 84, with plate.

BRANDIS, SIR D. . . On some Bamboos in Martaban. *Indian Forester*, xxxii, Nos. 4, 5, and 6, pp. 179, 236, 288.

BURKILL, I. H. . . Gentianacearum species Asiaticas novas descripsit. *Journ. Asiat. Soc. Bengal*, ii, 1906, No. 7, p. 309.

BURKILL, I. H. . . A Parasite upon a Parasite, a Viscum apparently V. articulatum *Burm.* on Loranthus vestitus *Wall.*, on Quercus incana *Roxb.* *Journ. Asiat. Soc. Bengal*, ii, 1906, No. 7, p. 299.

BURKILL, I. H. . . See *Moore.*

BUTLER, E. J. . . Some Indian Forest Fungi. *Indian Forester*, xxxi, Nos. 10, 11, 12, pp. 548, 661, 670.

COOKE, T. . . . The Flora of the Presidency of Bombay, vol. II, Part II.

DUTHIE, J. F. . . . A new species of Diospyros. Diospyros Kanjilali. *Indian Forester*, xxxi, No. 6, p. 307, with plate.

FINET ET GAGNEPAIN . Espéces nouvelles de l'Asie Orientale. *Bull. Soc. Bot. de France*, liii, No. 2, p. 125.

FINET ET GAGNEPAIN . Contributions, a l'etude de la flore dé l'Asie Orientale. *Bull. Soc. Bot. de France*, Memoire 4, 1905.

GAGE, A. T. . . . Eugenia praetermissa, a hitherto undescribed species from Assam and Burma. *Indian Forester*, xxxii, No. 1, p. 6, with plate.

GAGE, A. T. . . . Hedyotis sisaparensis, a hitherto undescribed Indian species. *Journ. Asiat. Soc. Bengal*, i, 1905, No. 9.

GAGE, A. T. . . Wormia Mansoni, a hitherto undescribed species from Burma. *Journ. Asiat. Soc. Ben.*, ii, 1906, No. 3, p. 73.

GAGE, A. T. . . Bulbophyllum Burkilli, a hitherto undescribed species from Tenasserim. *Journ. Asiat. Soc. Ben.*, ii, 1906, No. 8.

GAGNEPAIN, F. . . Zingibéracées nouvelles de l'herbier du Museum. *Bull. Soc. Bot. France*, 1906, liii, pp. 132—150.

GAMMIE, G. A. . . The Orchids of the Bombay Presidency, Parts II and III. *Journ. Bombay Nat. Hist. Soc.*, xvi, No. 4, p. 562, and xvii, No. 1, p. 31, with 2 plates.

GERSCHON, S. . . Variationen von Jussieua repens. *Abhandl. der Kais. Leop. Karol. Deutsch. Akad. d. Naturforcher.* Bd. lxxxiv, 1905, with 4 plates.

HOOKER, SIR J. D. . . An Epitome of the species of Impatiens of British India, Parts II and III. *Records Bot. Survey of India*, iv, Nos. 2 and 3.

KING, SIR G., & GAMBLE, J. S. Materials for a Flora of the Malayan Peninsula, Nos. 16, 17, 18. *Journ. Asiat. Soc. Beng.*, i, Extra Number, 1905.

LEAL, F. . . The Origin of Anonas. Anona squamosa *L.* Anona reticulata *L. Journ. Bombay Nat. Hist. Soc.*, xvii, No. 1, p. 195.

MAYES, W. . . Note on the occurrence of a parasitic fungus on Pinus excelsa. *Indian Forester*, xxxi, No. 7, p. 369.

MOORE, S. LEM., & BURKILL, I. H. Swertiam novam japonicam ex affinitate S. tetrapteræ *Max.* descripserunt. *Journ. Asiat. Soc. Beng.*, ii, No. 7, p. 329, 1906.

OSTENFELD, C. H. . . A List of plants collected in the Raheng District, Upper Siam. *Bull. l'Herb. Boissier*, 2nd Ser., 1905, No. 8, p. 729.

PIERRE, L. . . . Plantes nouvelles de l'Asie tropicale. *Bull. Soc. Bot. de France*, lii, No. 7, p. 490.

PRAIN, D. . . . The species of Meconopsis. *The Gard. Chronicle*, xxxvii, No. 964, p. 369.

PRAIN, D. . . . The Genus Ceratostigma. *Journ. of Botany*, xliv, No. 517, p. 4.

PRAIN, D. . . . Mansonieæ, a new Tribe of the Natural order Sterculiaceæ. *Journ. Linn. Society*, xxxvii, No. 259, p. 250, with plate.

RAO, M. RAMA . . Chickrassia tabularis. *Indian Forester*, xxxii, No. 2, p. 55.

SCHLECHTER, R. . . Neue Orchidaceen de Flora des Monsun-Gebietes. *Bull. l'Herb. Boissier*, 2nd Ser., 1906, No. 4, p. 295.

SCHNEIDER, C. K. . Die Gattung Berberis (Euberberis). *Bull. l'Herb. Boissier*, 2nd Ser., 1905.

SPIRE, DR. . . . Contribution á l'étude de la flore Indo-Chinoise. *Bull. Soc. Bot. de France*, lii, No. 7, p. 551.

STEBBING, E. P. . . On the Cecidomyid [Cecidomyia (?) sp.] forming the Galls or Pseudo-cones on Pinus longifolia. *Indian Forester*, xxxi, No. 8, p. 429.

STAPF, O. . . . The Aconites of India. *Annals Royal Bot. Garden, Calcutta*, x, Part II, with 25 plates.

TALBOT, W. A. . . The Distribution of the Forest Flora of the Bombay Presidency and Sind. *Indian Forester*, xxxii, Nos. 1, 2, 3, pp. 8, 56, 126.

TILLMAN, O. J. . . The Embryosac and Embryo of Cucumis sativus. *The Ohio Naturalist*, vi, 1906, pp. 424—427, with 3 plates.

TROTTER, A. . . . Ulteriori osservazioni i tubercoli radicali de Datisca cannabina. *L. Bull. Della Soc. Bot. Ital.*, Nos. 3—4, 1906.

WILLIAMS, F. N. . . Liste des plantes connues du Siam. *Bull. l'Herb. Boissier*, 2nd Ser., 1902, pp. 428, 949.

AGRICULTURAL BOTANY.

BY

E. J. BUTLER, M.B., F.L.S.,

Imperial Mycologist.

Cereals and Food Stuffs.—The difficult botanical investigation of the cultivated races of Juar (*Andropogon Sorghum*), grown in India, has been continued. A general botanical study of these is in progress in the office of the Reporter on Economic Products, and a first paper has been published as an Agricultural Ledger (No. 6 of 1905) on *Sorghum vulgare*—the Great Millet in India—by Sir George Watt. This will soon be followed by a fuller account of the races of Juar. In Madras a bulletin has been published on the same subject by Mr. C. Benson, Deputy Director of Agriculture, in which an account of the Madras varieties is given on the basis of a provisional classification by Mr. I. H. Burkill. Mr. Gammie, Economic Botanist, Bombay, has in hand a similar study of the Bombay races.

A considerable amount of information on the subject of wheat cultivation was collected for the second annual meeting of the Board of Agriculture, held in January 1906, and has been published as an appendix to the Proceedings of the Board. A further investigation has been taken up by Mr. A. Howard, Imperial Economic Botanist, who is compiling an account of the work done up to date, to be followed by a further botanical study. As a basis for accurate classification, Mr. Howard has accumulated most of the known Indian varieties at Pusa, where they have been grown during the past season and botanically examined. As was anticipated, most of the races were found mixed, and the separation of the types has proved a laborious matter. In addition to observing the varieties as grown at Pusa, Mr. Howard visited the Central Provinces and Punjab to study many of the chief kinds in their native homes. This inquiry should throw

some light on the correctness or otherwise of the statement often made that many of the races are liable to change their characters when introduced into other climatic areas. It is obvious that no accurate information on this point can be gained by working with mixed strains, as most of the so-called races have proved to be, and the first essential is therefore to obtain pure types for further investigation. These types have also provided material for hybridization work, and numerous successful crosses have been obtained. A scheme for future work on the improvement of Indian wheat was settled by the Board of Agriculture. Mr. Gammie has continued his botanical study of the varieties of wheat grown on the Poona Government Farms, and has also in hand a similar study of rices grown at Poona and Lonaola. An Agricultural Ledger on the rice known as *Oryza coarctata* is in preparation by the Reporter on Economic Products.

Mr. Burkill and Lieutenant-Colonel Prain are collaborating in a large review of the yams of India which is not yet completed.

Mr. Barber, Government Botanist, Madras, has continued his work on the varieties of sugarcane in parts of the Madras Presidency, and on those which have been introduced on the experimental sugarcane station at Samalkota. The imported Mauritius canes have been botanically examined in the field, and arrangements made with the Director of Forestry in Mauritius for their determination. This is intended to clear up the serious confusion which now exists as to the identity of these canes. Mr. Barber has also drawn up, for the Inspector-General of Agriculture, a scheme for inquiry into the sugarcane industry in India, to be conducted by the various provinces in preparation for the next annual meeting of the Board of Agriculture, where the subject will be fully discussed.

Mr. Burkill is engaged on a study of the races of *Lathyrus sativus* in India, and an account of the disease known as lathyrism, induced by the consumption of poisonous forms of this pulse, has been published by Major Buchanan.

Mr. Barber has prepared an illustrated account of the varieties of pepper growing in the Wynaad plantations which is published as a Bulletin of the Madras Department of Agriculture. Arrangements have been made at the special pepper farm at Taliparamba in Malabar, founded last year, for a full botanical and agricultural investigation of this important product.

The inquiries into Indian caraways, pan, barley, Goa bean, Burmese pulses, plantains, and chillies are still in progress in the office of the Reporter on Economic Products.

Experiments in the cultivation of dates (*Phœnix dactylifera*) have been started in the arid tract of Sindh, where the climatic conditions appear to be suitable. The best varieties have been obtained from many countries, and are now being tested. An account of the cultivation of date-palm has been published by Mr. Fletcher, Deputy Director of Agriculture, Bombay, as an Agricultural Ledger.

Fibres.—The work on the improvement of Indian cotton, alluded to in last year's report, has continued. The most important feature of the year has been the success in its preliminary stages of the attempt to introduce Egyptian cotton in Sindh, carried out by Mr. Fletcher, Deputy Director of Agriculture, Bombay. The cotton was under irrigation and after Egyptian methods, and some of the produce realised as high a price as 10*d.* per lb. in Liverpool. A considerable area (about 6,000 acres) has been sown this year, and the results should provide a reliable indication of the ultimate value of the experiment.

Mr. Gammie has published a paper dealing with the species and varieties of Indian cottons, their respective distribution, the quality of their lint and similar matters, and a revised account, with coloured illustrations of the chief types, is under preparation. A description of some Indian cottons which have not yet been studied in cultivation at the Government Farms is being prepared for publication by Mr. Burkill. The other lines of work on the improvement of Indian cottons, such as hybridization, the cultivation of tree cottons, and so on, mentioned in last year's report, are still in progress on various Government Farms and elsewhere, but no results calling for mention have as yet been published.

Mr. Burkill is collecting information regarding the varieties of jute in cultivation, in conjunction with the Department of Agriculture. Further experience has only confirmed the conclusions arrived at by the Sub-Committee of this Board, reported in 1904, that the alleged deterioration of jute fibre reaching the market is due, not to any deterioration of the plant itself, but to fraudulent watering and the shortage of supply which forces buyers to purchase even the most inferior qualities. The obvious remedy for this is the extension of the area under jute cultivation in India.

The inquiry into the source of "sunn" hemp was continued at the Royal Botanic Gardens, Calcutta. A paper on the botanical classification of Indian grown agaves, by Lieutenant-Colonel Prain and Mr. J. R. Drummond, is in the Press.

Oils, Dyes, Drugs, etc.—The botanical investigation of the lemon grasses (yielding citronella oil) has received special attention from Mr. Barber during the year. It has been made abundantly clear that the subject is involved in confusion and that detailed inquiry is necessary to obtain authoritative information regarding the value of the varieties yielding this important product. A method for treating the seed of the newly introduced Natal indigo to promote germination was suggested by the writer and has been elaborated by Mr. C. Bergtheil, Imperial Bacteriologist, who is in charge of the indigo research station at Sirseah. It consists in immersing the seed in strong sulphuric acid for a definite period. The application is more simple than, and at least equally effective as, the cumbrous treatment by machinery previously used. A paper, giving the results of his investigation into the nature of the hard seed coat, has been prepared for publication by Mr. Bergtheil.

Several botanical specimens of trees allied to the camphor tree have been received from Burma by the Reporter on Economic Products, and these will form the subject of investigation with regard to their possible value as camphor yielders.

Tobacco improvement was the subject of a discussion at the last annual meeting of the Board of Agriculture, and a scheme for future investigation was drawn up. This will entail a certain amount of botanical work, but the botanical side of the enquiry has not yet been commenced.

Mycology and Plant Pathology.—Mr. Barber has contributed a note on the occurrence of the root parasitic weed *Striga*, on paddy, to the Agricultural Journal of India. This is but a part of a large investigation which the Madras Government Botanist has undertaken into the root parasites of Southern India. As, however, the majority of these are not agriculturally important, further mention is not required here. The addition of an assistant for mycology to Mr. Barber's staff has enabled him to carry out preliminary investigations of a number of plant diseases. The work of the special sugarcane, ground-nut, and pepper farms under Mr. Barber's supervision has been in part concerned with the diseases of these crops.

Dr. H. Mann, Scientific Officer of the Indian Tea Association, has issued a bulletin on the fungus disease known as "blister blight" of tea which is caused by *Exobasidium vexans*; the life-history of this destructive blight is given, out-breaks are shown to be the result of well-defined causes, and preventive measures are described. Mr. Hutchinson, of the same Association, has in preparation a technical account of the "red rust" of tea, caused by the alga (*Cephaleuros virescens*).

A considerable amount of systematic work has been done by the Imperial Mycologist, with assistance from outside India. Arrangements have been made for the publication of the Indian species of rusts and smuts in the Herbarium at Pusa, in conjunction with Herr H. Sydow of Berlin. About two hundred and fifty species have been collected, being nearly double the number of Indian species previously known, and these have been despatched to Berlin after the greater part had been named. The new species contain several forms of great interest. Collections of higher fungi have been sent to Mr. G. Massee, of Kew, who has published several new species in the Kew Bulletin. The collection of wilt disease producing fungi has been sent to Dr. W. Busse, of Berlin, for critical examination. Mr. E. Salmon, of Wye, has continued his interest in Indian mildews (*Erysiphaceæ*), and further collections have been sent to him. A monograph of *Pythiaceæ*, a group of lower fungi, has been written by the Imperial Mycologist and is now in the Press. Several minor collections of *Gasteromycetes* have been sent to Professor Lloyd, of Cincinnati.

The main work of the Imperial Mycologist has been, as usual, the study of plant diseases, of which the following are the chief. An account of the wilt disease of pigeon-pea and pepper was published in the Agricultural Journal of India, and further work with this disease is in progress. Sugarcane diseases are still under study, and a revised memoir on those prevalent in Bengal is published in the Memoirs of the Department of Agriculture in India. The checking of "red rot" (*Colletotrictum falcatum*), by far the most serious cane disease, has been found entirely practicable in Behar, and knowledge of the mode of spread of the disease has been obtained, which should be of much value. Work on cereal rusts has been continued, and an account of the observations made up to date, in conjunction with Mr. J. M. Hayman, Deputy Director of Agriculture, United Provinces, is also

published in the Memoirs of the Department of Agriculture in India. A brief note on the bearing of Mendel's laws of heredity on the susceptibility of wheat to rust was published in the Journal of Agricultural Science. Considerable alarm has been caused in the Godavari Delta by the outbreak of an epidemic disease of palmyra and cocoanut palms. The cause of the disease was determined, after a local investigation, the affected area mapped, and proposals made for an organized attempt to stamp it out before it extends further. All the indications point to the probability that it can be stopped by prompt measures, and the suggestions made for treatment are under consideration by the Madras Department of Agriculture. An account of this and some other palm diseases has been contributed for publication in the Agricultural Journal of India.

From time to time suggestions have been made for checking outbreaks of insect pests by the dissemination of disease amongst them. Several cases are known of the occurrence of fungus parasites in harmful insects. One of the most noted of these is the locust fungus, which has been stated to destroy locusts in South Africa. A series of tests with this fungus was carried out, in conjunction with the Imperial Entomologist, on the Bombay and North-Western locusts, and some species of grasshoppers destructive to crops. In no case did any benefit result, and though in the case of the North-Western migratory locust there were some evidences of infection, still even here the method is clearly not of practical value in the field. A departmental report has been submitted.

Attempts have also been made to check the green bug of coffee in Southern India, by means of a fungus which attacks various scale insects. The parasite was imported from the United States, by the United Planters' Association of Southern India; some was applied directly to the infested coffee bushes, while some was sent to Pusa for culture. It was not found possible to get satisfactory cultures, and the attempt at direct inoculation also failed. As the parasite is not known to attack the coffee bugs in any country, this failure was not unexpected.

A commencement has been made at Pusa in the study of the fungi concerned in breaking down organic matter in the soil. A number of the chief soil species were isolated and determined.

List of publications dealing with Indian Agricultural Botany in 1905-06.

BOARD OF AGRICULTURE IN INDIA.	Proceedings for 1906.
BARBER, C. A. . .	The Samalkota Sugarcane Farm. *The Agric. Journ. of India*, i, part 1, 1906.
BARBER, C. A. . .	The Production of early maturing Canes. *The Agric. Journ. of India*, i, part 3, 1906.
BENSON, C., & SUBHA, C. K.	The Great Millet or Sorghum in Madras. *Depart. of Agric. Madras*, iii, Bulletin No. 55, 1906.
BUTLER, E. J. . .	The Wilt Disease of Pigeon-pea and Pepper. *The Agric. Journ. of India*, i, part 1, 1906.
BUTLER, E. J. . .	The bearing of Mendelism on the susceptibility of Wheat to Rust. *The Journ. of Agric. Science*, i, part 3, 1905, Cambridge.
BUTLER, E. J. . .	Fungus Diseases of Sugarcane in Bengal. *Mem. Depart. of Agric. in India*, Bot. Series, i, No. 3, 1906.
BUTLER, E. J., & HAYMAN, J. M.	Indian Wheat Rust. *Mem. Depart. of Agric. in India*, Bot. Series, i, No. 2, 1906.
FLETCHER, F. . .	Phœnix dactylifera *Linn.*, the Date Palm. *The Agric. Ledger*, No. 1, 1906.
GAMMIE, G. A. . .	The Indian Cottons.
MANN, H. H. . . .	The Blister Blight of Tea. *Indian Tea Assoc. Bull.*, No. 3, 1906.
WATT, SIR G. . .	Sorghum vulgare *Pers.*, the Great Millet or Juar in India. *The Agric. Ledger*, No. 6, of 1905.

Numerous minor notes in the Agricultural Journal in India.

FOREST BOTANY.

BY

H. H. HAINES, F.L.S., F.C.H.,

Imperial Forest Botanist.

General.—An account of the Flora of the Bombay Presidency,[1] dealing especially with its distribution from an œcological standpoint, has been published by Mr. Talbot, Conservator of Forests. The potency of the "Human Factor" directly, or indirectly through domestic animals, in influencing the character of a flora is again demonstrated. The evolution of the deciduous forests can in many places in North Canara and Belgaum be traced to the degradation and destruction of the evergreens by human agency. There are further sad records of the "ignorant treatment" of forest-covered lands resulting in the formation of large areas of barren and unproductive soil. Such denudation is unfortunately still in progress. One case is afforded by the cultivation of the Areca-nut palm which requires for leaf manure alone an area of forest six to nine times as great as the extent of the actual plantation.

In 1899 Sir D. Brandis wrote some Biological Notes on Indian Bamboos, and he has now considerably added to these in a résume of the bamboos of Martaban, with a description of their habits and mode of occurrence.[2] Thirty-two species are enumerated, of which thirteen are associated with the teak. Some notes on the bamboos in the Bombay Presidency are given in Mr. Talbot's work above quoted. The advantage accruing to bamboos by the rapid elongation of their young culms which places their tender buds quickly beyond the reach of most animals is alluded to. The amount of reserve material that has to be indented on by this rapid growth is not generally taken into sufficient account by foresters; the rotation fixed for the working of bamboo clumps is usually too short, and probably accounts for the great deterioration of the clumps which is apparent, for instance, in some of the bamboo woods in the United Provinces. A paper on the structure of bamboo leaves has been contributed to the Linnean Society by Sir D. Brandis.[3]

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[1] Published in Indian Forester, Vol. xxxii, Nos. 1, 2, and 3.

[2] Indian Forester, Vol. xxxii, Nos. 4, 5, and 6.

[3] Paper read before the Linnean Society in June 1906.

Seed of *Dendrocalamus strictus* sent from the United Provinces to Pretoria is reported to have germinated well, but the attempt to introduce this bamboo into Jalpaiguri seems a mistake, as Jalpaiguri is so near to the natural habitat of the species, that were the conditions there prevailing adapted to it, there is little doubt that it would be found naturally in that district. A new species of Eugenia (*E. praetermissa* Gage) was figured and described by Captain Gage.[1] It occurs in Assam and the Khasia Hills. The fruit, which is about the size of a small cherry, is largely eaten by the Lushais.

An investigation by the writer of some of the species of Populus[2] in the Himalayas has shown that 2-sexual flowers occur frequently in one species hitherto undescribed (*P. glauca* Haines) and also a well-developed perianth. Although female trees of this species occur, no males have been found. This rarity of one sex also occurs in other species of the genus. Another species had such markedly dimorphic twigs and leaves that it would have been impossible to have recognized the two forms as even allied had they not been found growing on the same individual in some cases. There was no opportunity of investigating this phenomenon which may have been caused by a parasite, or is perhaps a case of a partial mutation?

Mr. Duthie has described as new a species of Diospyros[3] (*D. Kanjilali* Duthie) which has hitherto usually been included with *D. montana*, Roxb. It is a fairly widely distributed tree.

Pathology.—The study of the diseases of trees in India is still in a very rudimentary state. Forest officers observe the chief external indications of disease, but they have neither the appliances nor the time for those laboratory studies which are necessary for the elucidation of the less obvious causes of disease, or for the study of the life-history of fungoid parasites, and it is fortunate that the damage done by parasitic fungi in the forests of India bears no comparison with that caused by browsing, fires, and uncontrolled felling and lopping. Among recent workers in this field, Messrs. McIntosh, Hole, Coventry, Mayes, and Troup have furnished a considerable quantity of material which has been worked up by Dr. Butler into a valuable

[1] Indian Forester, Vol. xxxii, No. 1.

[2] Paper read before the Linnean Society in June 1906.

[3] Indian Forester, Vol. xxxi, No. 6.

contribution[1] to the knowledge of our Himalayan fungoid diseases, and from this knowledge efficient palliative measures can in some cases be suggested. Mr. Mayes of the Forest Department has also contributed a further note on the occurrence of the destructive parasitic fungus *Trametes Pini* in the Simla Division which was referred to last year.

On the difficult question of spike "disease" in Sandal, experiments conducted by Messrs. Butler and Barber by budding and grafting diseased shoots of Sandal on to healthy trees, and specially exposing the wood of stems and roots of healthy trees to infection, appear to confirm the opinion previously expressed that spike is not an infectious disease.

FOREST PRODUCTS.

BY

M. HILL, F.L.S.,

Assistant Inspector-General of Forests to the Government of India.

Forest Research Institute.—With the object of providing for the continuous prosecution of research work connected with forest products, the Government of India have reconstituted the Dehra Dun Forest School as an Imperial Forest Research Institute and College. It is proposed that there shall be a staff of six experts who will make special studies in Silviculture, Forest Working-plans, Zoology, Botany, Chemistry, and Forest Economies. It is anticipated that the provision of such an Institute will lead to most valuable results in the scientific working and management of the State forests, the arresting of many of the diseases and pests which destroy large quantities of timber, the commercial utilization of many forest products at present unused, and the general advancement of scientific knowledge.

2. **Wood and Bamboo Pulp.**—Important investigations into the feasibility of utilizing in the form of wood and bamboo pulp, the inferior species of timbers and the large number of bamboos for which there is at present an insufficient demand, were made during the year. The services of Mr. Sindall, an expert in wood pulp, were obtained and he was directed to make practical enquiry and to conduct suitable

[1] Indian Forester, Vol. xxxi, Nos. 9, 10, 11, and 12.

experiments in Burma, in which province there are large quantities of unutilized timbers and bamboos. Accordingly a temporary experimental laboratory was fitted up at Rangoon and a number of samples of wood, bamboo and other fibres were experimented with. Investigations were also made in regard to suitable sites for pulp or paper mills. Some trials were made with wood and bamboo treated by the Sulphite process and the results showed that pulp could be prepared in this way, but the majority of the experiments were made to ascertain the strength and quality of the fibres by isolation of the Cellulose with Caustic Soda. The general outcome of the experiments went to show that the pulp produced from the Burmese woods experimented with, whilst it might find a local use in Burma for the manufacture of cheap paper, would not enter into serious competition with the high class wood pulps obtainable in England, if exported as paper pulp to that country.

The results of the experiments with bamboos were however more promising, and it is considered that the manufacture of paper pulp would be practicable from a commercial point of view; the prospects of an export trade for unbleached bamboo pulp appear to be favourable, having regard to the excellent quality of the pulp prepared under favourable conditions.

It is estimated that a ton of unbleached bamboo pulp could be produced for £5-10-0 including manufacturing costs, interest and miscellaneous charges. This cost, supplemented by the freight to England and sundry dues would be increased to £7-10-0 as the price delivered to London or Liverpool. Considering the quality of the pulp a profit should be realised since wood pulp is valued at £8 to £9 a ton.

The manufacture of bleached bamboo pulp for export does not however appear to be promising chiefly in consequence of the high cost of importing bleaching powder and to the deterioration of this chemical in a warm climate.

The value of the pulp for local use in a paper mill in Burma is considered undoubted, and the manufacture of paper from bamboo offers favourable possibilities as a new industry for Burma.

3. **Effect on Timber of the Tapping for Resin.**—Investigations were made during the year to ascertain whether the tapping of Pine trees for resin leads to a deterioration of the timber, or retards the rate of growth. The results of the experiments made so far go to show that the

transverse strength of tapped timber is greater than that of untapped timber, that carefully regulated tapping does not injuriously affect the quality of the timber, or retard the growth of the trees or cause their death. Meanwhile the results of somewhat similar experiments undertaken by the Agricultural Department of the United States have become available and they are said to prove conclusively (1) that tapped timber is as strong as untapped if of the same weight; (2) that the weight and shrinkage of the wood is not affected by the tapping; (3) that tapped trees contain practically neither more nor less resin than untapped trees, the loss of resin referring only to the sapwood, and therefore the durability of the timber is not affected by the process of tapping.

4. **Lac.**—The importance of lac cultivation in India is very great; the value of the exports of lac in the form of button, shell, stick lac and other kinds amounting to nearly three crores of rupees annually, but hitherto little or nothing has been done to ascertain how the cultivation of the lac insect could be improved and extended, and what is the best season for gathering lac. Lac dye possesses practically no commercial value, and its presence in the lac and the necessity for removing it cause the greater part of the trouble attending the industry. It appears that after the larvæ have swarmed out practically no colouring matter remains, and that the lac after the swarming has all desirable properties as fully as before the swarming. Nevertheless it seems that it is invariably the practice of the people to gather the lac before the swarming. During the year the Forest Department, in co-operation with the Director-General of Commercial Intelligence who instituted enquiries on the subject, collected information to ascertain definitely if it is the common practice of the people to gather the lac before swarming, and whether they could be taught to wait till after swarming before collecting it. Samples of lac gathered after swarming were also obtained with the object of making experiments regarding the possibility of quickly separating the lac proper from the vegetable and animal contaminations, by trituration and centrifugal washing. It is proposed to plant suitable areas in the chief lac-growing districts with those species of trees which have in practice been found to support lac while young, to inoculate the plants with lac two or three years hence, and to have the lac gathered under ascertained conditions and observation when the swarming of the larvæ (not of the winged males) has taken place. If the effects of this experiment be such as the facts

seem to point to, and if the lac be obtained free from the objectionable dye and exuviæ, it is possible that an impulse may be given to this important industry. There is reason to fear that the high prices ruling for lac in recent years have led to reckless gathering without regard to future crops.

5. **Tannins.**—Some important experiments were made in connection with Professor Dunstan's decolourising process. Extracts of the barks of *Terminalia tomentosa*, *Shorea robusta*, and Mangrove (*Rhizophora mucronata*) were treated in accordance with this method, and samples of these, together with samples of untreated extracts, were sent to England for analysis and trial, the results are not at present known. It appears probable that extracts from mangrove bark which is very rich in tannin will lead to the most successful commercial results as the extract is pure, keeps well and is easy to manufacture, also the ratio of extract obtained to the quantity of bark used is a great deal more favourable than in the case of other species experimented with.

It has been ascertained that dried mangrove bark can be used with great advantage and saving in cost of carriage, as if stored properly it retains its tannin producing qualities for a considerable period. The ratio of bark stored for a year, to extract was found to be 1·46 to 1, whereas with newly stripped bark the ratio was $3\frac{1}{2}$ or 3 to 1.

6. The Forest Department collaborated as usual with the Reporter on Economic Products to the Government of India, in the collecting, testing and reporting on a large variety of Forest Products from all parts of India and Burma including gums and resins, rubber, oils and oil seeds, wax, dyes and tans, cutch, fibres and fibre-yielding barks, medicinal fruits, seeds, bark roots, etc., narcotics, edible substances (food and fodder), canes, bamboos, and timbers. The following is a brief account of the results of some of the examinations made by the Reporter on Economic Products.

7. **Rubber.**—Examination of samples of rubber obtained from various species of Ficus tend to show that of the many species of wild fig in India only *Ficus elastica* yields satisfactory India rubber, no others yield a latex approaching in composition true India rubber. Experiments were made with the gums obtained from Artocarpus trees. These gums in a fresh state are soft and tenacious, somewhat similar

to bird-lime, and very gradually dry into hard resinous masses. Three species were analysed with the following results:—

	Caoutchouc.	Resin.	Ash.
Artocarpus hirsuta . . .	28·0	71·0	1·0
„ calophylla . . .	21·6	75·8	2·6
„ integrifolia . . .	7·7	90·3	2·0

Samples of dried latex from *Bassia latifolia* were examined and were found to yield on an average 49 per cent. of gutta, 38·7 per cent. of resin and 12·3 per cent. of ash. A specimen of gum from *Bassia longifolia* from Tinnevelly yielded 22·6 per cent. gutta, 62·7 per cent. resin, and 14·7 per cent. of ash. This corresponds with the gutta obtained from *Bassia Motleyana* of Perak, which is however considered to be of inferior quality by experts. The gutta of *Dichopsis obovata* from Burma was again examined: the practical outcome of the enquiry is that, although the tree is fairly abundant in Tenasserim and Mergui, the gutta could not be extracted commercially as the rates obtainable are unfavourable. A number of rubbers of minor importance were analysed including *Alstonia scholaris*, said to furnish the "Gutta Pulci" of Singapur. An examination of some juices of Euphorbias showed that they are not suitable substitutes for Caoutchouc.

8. **Dyes.**—Among the dyes examined was that of "Kamala", which consists of the glands of the fruit of *Mallotus philippinensis*. During the year an Agricultural Ledger was published incorporating the results of enquiries made by Forest Officers in all parts of India, together with the conclusions of the technical researches conducted in England.

9. **Food Stuffs.**—Several articles were examined to ascertain their value as famine foods, among these was the root of *Costus speciosus*, obtained from Assam, Bengal, and the United Provinces, it was found to be fairly nutritious and a description of the root with its analysis is being published in an Agricultural Ledger.

10. The fibrous root of *Sterculia villosa*, used as a famine food in the United Provinces, was found to be very innutritious, its nitrogen content being very low, and the amount of fibre and insoluble ash excessive.

11. The seeds of *Ormosia tavoyana* from Burma were analysed to ascertain their value as a food for cattle. The result showed that the powdered seeds, which are palatable, are comparatively nutritious,

12. An interesting discovery was made of a manna in the Central Provinces. It was obtained from the tree *Schrebera swietenioides*, from which it exudes in the form of a white sweetish gum. The mannas hitherto found in India have been obtained from various shrubs and trees, removed from the Manna Ash, but the Schrebera is a tree of the natural order Oleaceæ, which includes the ash trees from which the commercial manna of Europe is obtained.

13. A preliminary examination was made of an acid food from Assam which appears to be made from the young shoots of the common bamboo (*Dendrocalamus Hamiltonii*) by a process of fermentation. The acid seems to be derived from the asparagin of the growing shoots of the bamboo, by chemical decomposition.

14. **Botanical Specimens.**—Numerous botanical specimens, and a variety of timbers of different species were collected by the Forest Department in most Provinces and supplied to the Director, Botanical Survey of India, the Reporter on Econonic Products, the Sibpur Engineering College, and to other Institutions and Museums, including the Arnold Arboretum, America, to which institution several specimens of the Indian species of Pinus were sent.

15. **Seeds.**—The seeds of many indigenous Indian species are now annually supplied for experimental cultivation in British and Foreign Colonies.

During the year the Forest Department supplied the following:—

Several species of Pinus to the Forest Department, Mauritius, seeds of Oaks, Pines, Juniper, *Dalbergia Sissoo*, *Cedrus Deodara* and bamboos to the Forest Departments of Cape Colony and the Transvaal, and Teak seeds to the Forest Department, British East Africa Protectorate.

Seeds of several species of bamboos were supplied for cultivation in German East Africa, and seeds of padouk (*Pterocarpus dalbergioides*) for trial in the Federated Malay States.

List of books and papers bearing on Forestry, Forest products, etc., in India, received or issued during 1905-06.

EARDLEY-WILMOT, S. . Review of Forest Administration in British India for 1903-04.

HOOPER, D. . . . Schleichera trijuga. *Agri. Ledger, No. 1, 1905.*

HOOPER, D. . . .	Kamala (dye from Mallotus philippinensis). *Agri. Ledger, No. 4, 1905.*
JACQUOT, A. . . .	Incendies en Forêt.
NISBET, JOHN . . .	The Forester (two volumes).

THE PROGRESS OF INDIAN ZOOLOGY, 1906.

BY

N. ANNANDALE, B.A., D.Sc.,

Officiating Superintendent, Natural History Section, Indian Museum.

The present report deals with the progress made during the year in the study of Indian Zoology and particularly with the work done in the Natural History Section of the Indian Museum.

I.—Work done in the Indian Museum.

The zoological work done in the Indian Museum may be considered for the purposes of this report under three headings:—(*a*) arrangement of the collections not exhibited to the public; (*b*) important additions to the collections; and (*c*) original research.

(a) **Arrangement of Collections in the Indian Museum.**—The naming, labelling, and arrangement of the following groups in the reserve collections have been completed during the year:—Oriental Tortoises; Sea Snakes (Captain *F. Wall*, I. M.S.); Amphibia (Mr. *G. A. Boulenger*, F.R.S., British Museum); Shells of the genus Arca (M. *A. Lamy*, Paris); Hemiptera, Heteroptera, Cicadidæ and Fulgoridæ (Mr. *W. L. Distant*, London); Earwigs (Mr. *M. Burr*, London); Prawns of the genus Peneus; Crustacea Cirripedia (M. *A. Gruvel*, Bordeaux); Indian Freshwater Entomostraca (Mr. *R. Gurney*, Norfolk).

The names in italics are those of specialists not connected with the Museum who have examined the whole or a part of the collection in each group and reported on and returned the specimens. In the case of each group, specimens of Indian species have been labelled with labels printed in black, and those of exotic species with labels printed in red. So far as the limited space in the research rooms of the

Museum permits, each group has been arranged in taxonomic order, so that a very substantial addition to the permanently arranged collections has been made.

The complete collections in the following groups have been sent abroad during the year and are still under examination:—

Nematode worms to Dr. von Linstow, Göttingen; Gordiid worms to Professor Camerano, Milan; Earthworms to Dr. Michaelsen, Hamburg; Polyzoa to Miss E. Thornley, Liverpool; Brachiopods to Professor Joubin, Paris; Neuroptera to Professor J. G. Needham, Lake City, U. S. A.; and Parasitic Hymenoptera to Dr. Ashmead, Washington, U. S. A.; as well as recent additions in several previously arranged groups sent to other specialists. The staff of the Museum has been taxed to the utmost in conducting the correspondence and sorting of specimens which the above work has entailed.

(b) **Additions to the Collections in the Museum.**—The most important additions of scientific value made to the collections during the year have been obtained by the Indian Marine Survey and the staff of the Museum, the subordinate members of which have been encouraged to collect insects and other animals during their spare time and while on leave. An attempt has been made, so far as the opportunities of the Museum permit, to obtain a representative collection of the less conspicuous elements in the fauna of the Himalayas and so to study the distribution of these elements. With this end in view an officer of the Museum has made collecting trips in the Darjeeling District and Kumaon, and has obtained numerous specimens of new and interesting species. A gallery assistant has been sent into Nepal with the same object, Major Manners Smith, the Resident, having made the necessary arrangements. This collector has not yet returned, but the Resident reports that he is hard at work. The Officiating Superintendent has paid special attention to the fauna of the Calcutta tanks, which was previously almost unknown, and has obtained a large series of sponges, polyzoa, entomostraca, and aquatic insects; while a valuable collection of earthworms—a most important group in any zoo-geographical inquiry—has been got together with the aid of correspondents in different parts of India.

Marine Zoology.—It cannot be said, however, that research has not been done. In the direction of Marine Zoology, Colonel Alcock has published officially, as part of the Museum Catalogue of Decapod

Crustacea, an important monograph on the prawns of the genus Peneus and their allies—a group hitherto in great need of revision. The same author published earlier in the year a preliminary classification of these prawns in the Annals and Magazine of Natural History. Dr. Annandale has published in the same periodical a preliminary report on the stalked barnacles in the collection, as well as several shorter notes on the same group in the Annals and in the Journal of the Asiatic Society of Bengal. Captain Lloyd, I.M.S., Surgeon Naturalist on the R. I. M. S. *Investigator*, has worked in the Museum on new deep-sea fish; and Captain Wall, I.M.S., has published in the Memoirs of the Asiatic Society of Bengal. an account of the sea-snakes in the collection, with new diagnoses of all the species represented. In the Journal of the Society the Officiating Superintendent has written on the Dugong in the Gulf of Manaar.

Fauna of the Calcutta Tanks.—A number of short notes have been published regarding the fauna of the Calcutta tanks in the same Journal, as well as a more detailed memoir on the freshwater polyp of Bengal in the Memoirs of the Society.

Terrestrial Zoology.—The Officiating Superintendent has published in the same Memoirs an account of the herpetology and entomology of Rámanád in Madras, which he visited on behalf of the Museum in 1905, and also several short papers, in the Journal of the Society, on reptiles in the collection of the Museum. Mr. C. A. Paiva, Entomological Assistant, has published in the same Journal notes on additions to the collection of insects made during the year.

Indian Rats.—Dr. W. C. Hossack, District Medical Officer, Calcutta, working in the Museum, has done important research on the rats of Calcutta, only a preliminary note (in the same Journal) on which has as yet appeared. This work is of direct practical importance in connection with the distribution of plague. It might advantageously be extended to other parts of India with the assistance of the existing plague organization. At present the greatest confusion reigns as regards the distribution and bionomics of the Indian rats, and this confusion can only be dispelled by the examination of a large series of specimens from each locality. Enormous numbers of rats are now killed by Government orders in different parts of India; but as a rule their bodies are destroyed without examination. It is not impossible that indiscriminate destruction of rats may in certain cases

be at least a wasteful procedure, and it is almost certain that all species are not equally dangerous. Dr. Hossack has generously presented his collection of skins and skulls to the Museum, where they will prove a valuable source of reference.

II.—Work done outside the Museum.

As regards the zoological work affecting India done outside the Museum during the year, all that can be offered is an imperfect summary. The early date at which this report must be submitted makes it impossible to include certain papers published in Europe. As the Imperial Entomologist and the Professor of Forest Zoology are presenting separate reports, no further mention need be made here of the work done in the departments they represent.

Protozoa.—Several officers of the Indian Medical Service have published during the year research on Protozoa which is of zoological as well as pathological importance. Major L. Rogers has continued his work in the Proceedings of the Royal Society on the Hæpatomonas of Kal-azar fever. In the Scientific Memoirs by officers of the Medical and Sanitary Departments, Captains S. R. Christophers and W. S. Patton, of the Indian Medical Service, have described blood parasites of the Antelope Rat and the Palm Squirrel respectively. In England Professor E. A. Minchin and Mr. H. B. Fantham have described a new Sporozoon which infests the human nose in India; while Messrs. Castellani and Willey's observations on Hæmatozoa in Ceylon are of great interest to Indian workers. The last two memoirs are in the Quarterly Journal of Microscopical Science.

Cœlenterates.—Professor J. A. Thomson and Mr. W. D. Henderson have recorded the existence of embryos in a number of Indian Alcyonacea (Zoologischer Anzeiger) and have concluded their work on the deep-sea members of this group in the collection of the Indian Museum. The latter will be published shortly by the Museum.

Nemertines and Nematodes.—Mr. F. F. Laidlaw, writing in the Annals and Magazine of Natural History, has published descriptions of two new genera of deep-sea Nemertines from the *Investigator* collections. Dr. von Linstow, of Göttingen, has described two new genera of Nematodes parasitic in the Long-nosed Crocodile of Bengal in the Journal of the Asiatic Society, in which he has also re-described the round worm of the Dugong. In the Zoologische Jahrbucher of

Jena the same author has described a new species of Nematode parasitic in *Cervus eldi*.

Arachnida.—In the Memoirs by officers of the Medical Department Captain S. R. Christophers has published a detailed account of the anatomy of certain ticks, while in the Journal of the Asiatic Society Dr. von Linstow has described a new Linguatulid. Mr. N. D. F. Pearce has described and recorded in the Quarterly Journal of the Royal Microscopical Society a number of Oribatid mites from Darjeeling. Herr W. Scheinkewitsch has worked out the embryology of the Whip Spider *Thelyphonus* (Zeitschrift für Wiss. Zoologie, Leipzig).

Crustacea.—In the Annals and Magazine of Natural History Dr. J. Henderson, of the Christian College, Madras, has given an account of a new coral-haunting crab obtained by the *Investigator* in the Andamans. Dr. J. C. deMan has described in the same Journal a new prawn from Darjeeling. Mr. R. Gurney has worked out the collection of freshwater Entomostraca in the Indian Museum (Journal of the Asiatic Society of Bengal). Papers by Miss M. Rathbun on freshwater crabs and by Mr. A. E. Ortmann on Schizopods, in the Archives of the Paris Museum and the Proceedings of the National Museum of the United States respectively, refer partly to Indian species.

Insects.—The papers on this group have, as is usually the case, been numerous. Only those which refer mainly or wholly to India can be noticed here. The only comprehensive monograph published has been the third volume on Rhynchota by Mr. W. L. Distant in the Fauna of British India series. Sir George Hampson and Mr. E. Meyrick have described numerous new Indian moths in the Journal of the Bombay Natural History Society, in which Mr. P. Cameron has also worked out a collection of non-aculeate Hyemnoptera from Baluchistan. Papers by a number of authors, who refer to or describe single species of Indian Hymenoptera, Neuroptera, Hemiptera, Lepidoptera, Diptera, and Coleoptera, will be found in the official publications of the National Museum of Hungary, the Berlin Natural History Museum, and the Imperial Museum of Vienna ; in the Annals and Magazine of Natural History, Novitates Zoologicæ, the Annals of the Entomological Society of France, the Tijdschrift voor Entomologie, the Berlin Entomological " Zeitschrift," and the Transactions of the Entomological Society. Dr. H. H. Mann has published in the

Journal of the Asiatic Society of Bengal an interesting account of investigations into the proportionate numbers of the sexes under different conditions in the case of the Mosquito Blight of tea (*Helopeltis*). Mr. M. Burr has catalogued the earwigs in the collection of the Indian Museum in two papers published in the same Journal.

Mollusca.—Mr. E. A. Smith, of the British Museum, has continued his paper on the *Investigator* Mollusca in the Annals and Magazine of Natural History. Professor Herdman has also published a paper on the gills of the pearl oyster in the Journal of the Linnean Society.

Pearl Fisheries.—The third volume of Professor Herdman's report on the Ceylon pearl fisheries contains, in addition to supplementary papers, an account of the fishery of 1904 by Professor Herdman and Mr. Hornell. The great importance of this work, not only to Ceylon, but equally to India, lies in the fact that its author has recognized, as a zoologist was bound to do, that it is impossible to deal with a problem which is fundamentally a biological one purely from an economic or statistical point of view. He has not been content to report on what he saw, and to give advice, but has called in the aid of other specialists in the different groups, to describe the collections which he made. Thus, when the work is completed, all that is known regarding the marine biology of the Gulf of Manaar and the Ceylon coasts will have been gathered within the compass of a single report, which will have a profound bearing on any inquiry as regards fisheries in other Indian seas.

Fishes and Fisheries.—It is understood from the daily press that an official report on the Madras fisheries has been issued; but the present writer has been unable to see a copy of this report, which has not been sent to the Museum. From the information accessible to him, it does not appear that the report deals with zoological questions. A scheme for a public aquarium at Madras has, it is stated, been drawn up and sanctioned. An institution of the kind should prove of the greatest practical and scientific value as regards Indian ichthyology. In connection with the Madras Government Museum a collection of the littoral fauna of the Presidency has, according to the Superintendent's annual report, been commenced or continued. A senior member of the Indian Civil Service has been appointed to report on the fisheries of Bengal.

As regards scientific papers on Indian fishes, the following have been received :—Mr. Tate Regan's description of two new species obtained by the Seistan Mission of 1903—1905, and Dr. W. Volz's account of the eyes of the Mud-skippers (Periophthalmus and Boleophthalmus), which can see both in water and in air. The former paper is published in the Journal of the Asiatic Society of Bengal, the latter in the Zoologische Jahrbucher.

Reptiles and Amphibia.—Mr. G. A. Boulenger has published descriptions of two new frogs in the collection of the Indian Museum (Journal of the Asiatic Society of Bengal). In the same Journal Mr. T. N. R. Aiyar, of the Pusa Agricultural Institute, has issued an account of the habits of sea-snakes common at Madras. In the Journal of the Bombay Natural History Society Captain F. Wall, I.M.S., besides describing several new snakes, has commenced a series of papers on Indian species and their identification. These should prove of considerable value to medical men and others interested in determining poisonous and harmless species. Lieutenant-Colonel W. B. Bannerman, of the same Service, has, in the same periodical, worked out the distribution of the different varieties of the cobra in India. It is not within the scope of the present report to deal with various physiological and pathological papers on snake-bite which have been published in medical journals and elsewhere.

Birds.—So much has been done on Indian birds, and so many papers still appear annually, that it cannot be said that research on this group has the same importance as that which still attaches to many others. The briefest list of papers is therefore sufficient. In the Bombay Natural History Society's Journal Mr. E. C. Stuart Baker has written on the oology of Indian cuckoos; Mr. B. B. Osmaston on Andaman birds; Mr. K. C. Macdonald on those of the Myingyan District of Burma; Mr. E. W. Oates on new Burmese pheasants; Lieutenant-Colonel R. H. Rattray on bird-nesting in the Murree hills; and Mr. J. W. N. Cumming on the birds of Seistan. In the Journal of the Asiatic Society of Bengal Lieutenant-Colonel D. C. Phillott has described the habits of the Houbara (*H. macqueenii*), a bird reputed to be destructive to opium in Persia. In the "Ibis" Captain H. J. Walton, I.M.S., has written two papers on the birds of South Tibet and the adjacent parts of Sikkim.

Mammals.—Dr. Lorenz von Libernau, in the "Denkschrift" of

the Imperial Academy of Mathematics and Natural Science of Vienna, has described the different races and species of the Ibex occurring in Central Asia including the Himalayas. In the Annals and Magazine of Natural History Mr. R. C. Wroughton has done the same for the Antelope Rats (*Tatera*) of Africa and Asia including India and Ceylon. In the Proceedings of the United States National Museum Mr. Gerritt S. Miller, Jr., has described the short-tailed monkeys of several Burmese and Malayan islands. Mr. G. Dalgliesh has published in the Journal of the Bombay Natural History Society notes on the Mammals of Darjeeling. In the American Naturalist Messrs. H. Dexler and L. Freund have published two papers on the anatomy and biology of the Australian Dugong, which appears to be identical with the Indian species. Mr. Oldfield Thomas has described a new variety of the Brown Bear from the Shan Hills (Proc. Zoological Society, London). Herr J. E. V. Boas has worked out certain peculiarities in the anatomy of the Indian Elephant (Gegenbaur's Morphologisches Jahrbuch).

III.—Summary.

Progress has been made in the arrangement and identification of the collections in the Indian Museum, which has continued, directly and indirectly, to foster research. A survey of the lesser fauna of the Himalayas and of that of stagnant water round Calcutta has been commenced in connection with the Museum. In India, apart from the Museum, valuable work on Protozoa and on Herpetology and Ornithology has been done by officers of the Indian Medical Service. The Christian College, Madras, has continued to encourage original work; while the Madras Government Museum, the chief energies of which are at present devoted to ethnology, is obtaining material for zoological inquiries in the future. In Bombay the local Natural History Society has been very active, while in Calcutta the Asiatic Society of Bengal has manifested renewed vigour as regards zoology.

Outside India, many new Indian species have been described by officers of the British Museum, while several public scientific institutions in Germany, Austria-Hungary, France, and the United States have been engaged with collections including Indian specimens.

Professor Herdman in England and Mr. Hornell, the resident marine biologist, in Ceylon have continued their work on the pearl-fisheries of the Gulf of Manaar and the Ceylon coasts, assisted by a

large number of other zoologists in Europe and India. This work deals with seas which are practically Indian and have a fauna which cannot be separated from that of the Indian coasts. The importance of the researches undertaken is very great, as they represent the first serious attempt to attack a marine biological problem of direct economic moment in a manner at once scientific and complete, as far as the seas round India are concerned.

AGRICULTURAL ENTOMOLOGY.

BY

H. MAXWELL-LEFROY, M.A., F.E.S., F.Z.S.,

Imperial Entomologist.

The study of the insect pests of crops was continued by the Imperial Entomologist, his staff and the Provincial Assistants. A detailed study of some insects not hitherto investigated was made partly in the newly-built insectory, partly in the field. The important outbreak of the bollworm of cotton (*Earias insulana* Boisd.) in the Punjab was enquired into, and assistance was given to the Agricultural Department in checking it. The spread of the Green Bug (*Lecanium viride* Gr.) in coffee in South India causes apprehension among planters and deserves to be closely watched. Other features of the year were the widespread occurrence of the Greasy Surface Caterpillar (*Agrotis ypsilon* Rott) and of the Rice Hispa (*Hispa ænescens* Baly). The efforts of trained assistants in the Provincial Agricultural Departments are gradually making themselves felt, and slow but real progress is being made in the adoption by cultivators of simple remedies for common pests. This will be aided by the publication of 'Indian Insect Pests,' a small volume on common crop pests written in simple language, the wide publication of which may be expected to promote a spread of more common sense views as to the origin and nature of insect epidemics.

In co-operation with Mr. R. S. Finlow, B.Sc., F.C.S., an enquiry was commenced by the Imperial Entomologist, to find out substances which may have a greater specific poisoning effect on insects than on mammals. A very large number of experiments was made and

interesting results obtained, which it is hoped may lead to the discovery of a useful form of poison harmless to cattle.

In co-operation with Dr. E. J. Butler, Imperial Mycologist, a trial was made of the South African Locust Fungus as a means of checking destructive locusts and grasshoppers. Further reference will be found in the Report on Mycology.

Further enquiries into the value of trap crops in Indian Agriculture, on the influence of climatic conditions on the prevalence of insect pests, and on the practicability of utilising beneficial insects as a means of checking pests, were carried on at the Pusa Research Institute.

Dr. H. H. Mann, Scientific Officer to the Indian Tea Association, has continued his study of the Mosquito Blight of Tea (*Helopeltis theivora* Sign), and his methods of checking it are extending in use among planters. Mr. C. B. Antram, newly appointed Entomologist to the Indian Tea Association, has commenced the study of two caterpillar pests of tea.

An enquiry is in progress into the prevalence in India of flies which, by biting man and domestic animals, may transmit diseases. A large number of specimens of flies biting cattle was also received through the Civil Veterinary Department. Collections of flies were sent for examination to the British Museum and to Germany, and a collection of ticks to Cambridge. The number of species of biting flies is far greater than was anticipated, and the discovery of two new species of *Lyperosia* which habitually bite man and cattle may ultimately prove to be one of much importance.

Progress has been made with the Insect Survey of India carried on in co-operation with the Indian Museum, Calcutta. The aid of specialists in Europe and America was obtained in working out the collections. The Pusa collections are now becoming valuable as reference collections of the Insect Fauna of the Plains of India, and every year sees an improvement in this direction. By limiting the area under survey to the Agricultural tracts, the collection will become of far greater value to students, will not overlap with other collections, and will become relatively complete in a shorter time.

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FOREST ENTOMOLOGY.

BY

E. P. STEBBING, F.L.S., F.Z.S., F.E.S.,

Imperial Forest Zoologist.

The Chief Economic Results of the Year.

a. By the Imperial Forest Zoologist.

The Quetta Borer (Æolesthes sartus).—The life-history of the insect known as the "Quetta borer," which had been devastating the avenues of the station of Quetta for several years, was completely worked out during the course of two visits made in May-June and October, respectively. The insect proved to be the cerambyx beetle *Æolesthes sartus*. This pest had gained a complete mastery over the trees forming

the avenues (chiefly poplars, willows, elms, etc.), all of which had been planted since the British occupation, and was rapidly exterminating them. So serious had the attack become that the only possible method of saving uninfested trees was to make heavy fellings on every road in the station. Both the Civil and Military authorities cordially co-operated in carrying out the recommendations made, the trees being felled and converted into fire-wood billets and charcoal during the winter season at which period the pest was in its larval and pupal stages within the trees. A certain number of infested trees were left as traps to attract the beetles issuing during the present year (1906) to oviposit in them. With the removal of these trap trees during the coming winter it is hoped that it will be possible to report that this pest has for all practical purposes been got rid of from the station. Felling operations were also undertaken at New Chaman where the insect had also badly infested the trees.

The Bark-boring Beetles of Zhob, and the Zhob Chilgoza Forests.—The Chilgoza (*Pinus Gerardiana*) forests of Zhob and Dera Ismail Khan (Shinghar, Sherghali, and the Takht-i-Suliman) were visited during June and November. It was found that portions of the forests were suffering from a severe attack of bark beetles, species of *Polygraphus*, *Phlœosinus*, and *Pityogenes* being the chief pests. The life-histories of these insects were studied and recommendations made for dealing with the attack. Several insects predaceous and parasitic upon the bark-borers were taken and notes made upon their life-histories.

The Sal and Mango Scale Insects.—A short tour in the areas of the United Provinces (Pilibhit, Naini Tal, and Kumaun) enabled investigations to be continued into the distribution of the Sal scale pest (*Monophlebus stebbingi*). A visit was paid to the Bareilly Public Gardens to examine the Monophlebus scale on the mango. It has not yet proved possible to obtain the male of this pest without which the species cannot be determined. The procuring of this insect is of some importance since the discovery that the two species are identical will increase the possibility of the scale spreading to the Sal tracts in other parts of the country.

Attacks of the Bark-borer Sphærotrypes in the Siwaliks Sal Areas.—The great frosts of February 1905 committed serious havoc in the Sal areas of the Dun and Siwaliks Divisions, large numbers of Sal trees being killed out and others either having the tops killed or

being reduced to a sickly condition. This has resulted in some increase in the numbers of the bark-borer *Sphærotrypes siwalikensis* which has been breeding in the sickly trees. This attack will require careful watching.

b. By other Departmental Investigators.

Discovery of the Cerambyx Beetle Hoplocerambyx spinicornis in the Central Provinces Sal Areas.—At the instance of the Inspector General of Forests, who first noticed the attack in the cold weather of 1905, Mr. Percival, Deputy Conservator, investigated the cause of dead and dying Sal trees in the Balaghat Division of the Central Provinces. The trees proved to be infested by cerambyx grubs, and it appeared that green trees were being attacked and killed by the insect. Excellent specimens were received from Mr. Percival, and the insect was identified as the pest *Hoplocerambyx spinicornis*, a beetle whose life-history I had partially worked out in 1897 in the Singbhum Sal tracts of Chota Nagpur. Further important observations on this pest have been made since the close of the year in the Sal tracts of Eastern Bengal and Assam.

The defoliator Gunda sikkima in the Charduar Rubber Plantation.—Mr. E. M. Coventry, Deputy Conservator, reported the defoliation of portions of the rubber trees in the Charduar plantation in Darrang, Assam, in October 1905. The insect proved to be the moth *Gunda sikkima*, the caterpillar of which had previously been reported as defoliating the *pipal* tree in various parts of India. This plantation was visited by the Imperial Forest Zoologist after the close of the year.

Weevil Girdling Padauk Seedlings at Port Blair, Andaman Islands.—Mr. B. B. Osmaston, F.C.H., submitted, with a note, specimens of a weevil (as yet undetermined) which had appeared near Port Blair in the padauk (*Pterocarpus dalbergioides*) taungyas and killed young seedlings and saplings of this tree. He reported that the insects appeared to be threatening the existence of the trees.

The defoliator Boarmia selenaria in Garhwal.—Mr. R. C. Milward noted that two generations of the Sal defoliator *Boarmia selenaria* made their appearance during the year in the Garhwal Division, and that damage was also done by the now well-known Monophlebus scale. He also submitted a valuable note on other Sal

defoliators. Mr. Mercer, Conservator, Western Circle, United Provinces, also submitted a note upon the scale pest.

Lymantria defoliator in Eastern Bengal and Assam Sal Tracts.—In Bengal the Sal trees were completely defoliated in the Jalpaiguri and Buxa Divisions by defoliating caterpillars of species of *Lymantria*.

Arbela tetraonis and Clania crameri in the Nellore Casuarina Plantations.—Casuarina trees in Nellore suffered from the attacks of the bark-eater *Arbela tetraonis* and the defoliator *Clania crameri*, the identification of which enabled prompt measures to be taken for their eradication. Numerous other at present incomplete observations and specimens were received from Bombay, Madras, United Provinces, Punjab, the Himalayan Region, Baluchistan, Burma, and the Southern Shan States.

c. By other Observers.

Help afforded by Authorities in combating the Quetta Borer.—The information received from and aid afforded by the Civil and Military authorities of Quetta, amongst whom I would mention Mr. Tucker, I.C.S., the Honourable the Agent, General Smith-Dorrien, and Major Archer, the Revenue Commissioner, in working out the life-history of the Quetta borer and in carrying out the steps necessary to rid the station of the pest were of the highest value.

Political Agent of Zhob's Action in connection with the Chilgoza Bark-borer.—The satisfactory results attained in the study of the Chilgoza bark-borers of Zhob were due primarily to the arrangements and help afforded by the Political Agent, Lieutenant-Colonel Chevenix-Trench, who had personally made investigations into the serious nature of the infestation. Under his supervision the recommendations made with a view to checking this pest were commenced in a most satisfactory manner.

Valuable observations were made by Major Kemball, Political Agent, Loralai, which were supplemented by Colonel Trench and Major Roome, Commandant, Zhob Levy Corps, into the life-history of a cerambyx beetle now known as the "Duki fig tree borer," an insect which is committing considerable damage amongst the fig trees in the fruit gardens of parts of Baluchistan.

The Quetta Borer at Chagai, Chaman, and Seistan.—Reports and queries on the subject of the Quetta borer were received from Major Benn, C.I.E., Assistant Political Agent, Chagai, and Captain

A. D. Macpherson, His Britannic Majesty's Consul at Seistan. The insect was also found to be numerous at Chaman.

Tree Avenue Pest in the United Provinces and Tanjore.—The Director of Land Records and Agriculture, United Provinces and Oudh, and the Collector of Tanjore requested advice on the subject of insect pests destroying avenue trees.

Hyblœa puera and H. constellata in Siam.—Mr. Taung Kamm, a Forest Officer in Siam, submitted for identification specimens of insects defoliating the teak in Siam. These proved to be *Hyblœa puera* and *H. constellata*, thus giving evidence of the presence of these pests in the Siam teak forests.

Demand for Assistance from Assistant Conservator, East African Protectorate.—A request was received from the Assistant Conservator of Forests, East African Protectorate, asking for permission to submit forest insect pests for identification.

Preservation of Bamboos from the Shot-borer (Dinoderus).—Officers of the Ordnance, Public Works, and Telegraph Departments submitted enquiries on the subject of the treatment of bamboos with Rangoon oil to prevent the attacks of the bamboo-boring beetles (Dinoderus). They were provided with copies of my published experiments on the subject of combating this pest.

Chief Scientific Results of the Year.

Distribution of Æolesthes sartus.—A discovery of curious interest was made in connection with the "Quetta borer," *Æolesthes sartus*. This beetle, although existing in thousands in the trees of the station of Quetta, had only previously been reported from Turkestan and Tibet. It is probable that it occurs in the soft wooded trees (poplars and willows) throughout Afghanistan and probably in parts of Persia.

The Chilgoza Pine Insects.—*New species of Polygraphus: P. Trenchi.*—The principal species of bark-boring beetles attacking the Chilgoza proved, as has been the general rule with scolytid pests in India, to be new to science. The Polygraphus was described as *P. Trenchi* in my note on the attack. The *Pityogenes* proved to be identical with *P. coniferæ* Steb., taken numerously in blue pine and deodar in the Himalayan coniferous forests. Among the predaceous insects taken, the Niponius proved identical with N. canalicolis, the

new species taken in the North-West Himalayas in 1901 and described by Lewis.[1]

Polygraphus sp. and Tomicus sp. in blue pine.—Species of *Polygraphus* and *Tomicus* were found infesting the blue pine (P. excelsa) on the Takht-i-Suliman Range. The interesting question as to whether these are identical with those infesting this tree in the North-West Himalayas still awaits solution.

Distribution of Hoplocerambyx spinicornis.—The notes on the fresh investigations and distribution of the cerambyx beetle *Hoplocerambyx spinicornis* in the Central Provinces are of considerable importance in view of the damage this pest commits in the Assam Sal tracts.

New Buprestidæ.—The discovery of the localities and food plants of several described species of *Buprestidæ* and of some new species has a scientific as well as an economic interest.

It is of considerable interest to note that the Siam teak forests are attacked by species of *Hyblæa* similar to those infesting the teak in Burma.

Literary work.—Amongst purely literary work may be mentioned the publication of the "Note upon the Quetta Borer (*Æolesthes sartus*)"; "The Chilgoza bark-borers of Zhob," in which a new species is described; the third number of "Departmental Notes on Insects that affect Forestry" (containing several descriptions of previously unrecorded *Scolytidæ*) completing Volume I; A note on the life-history of *Hoplocerambyx spinicornis*. The volume on *Buprestidæ* for the "Fauna of British India" series was nearly completed, and the series entitled "Insect life in India and how to study it" was continued in the Journal of the Bombay Natural History Society.

Co-operation of Experts.—Valuable co-operation in identification work was received from Messrs. Waterhouse and Gahan of the British Museum staff, Colonel C. T. Bingham, Editor of the *Fauna of British India*, Messrs. Lewes and Distant, *M.* P. Lesne of the Paris Museum, Dr. Horn of Berlin, and others.

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[1] Ann. Mag. Nat. Hist, Ser. 7, Vol. VIII, November 1906.

List of Publications.

STEBBING, E. P. . . A Note on the "Bee-hole borer" of Teak (*Duomitus ceramicus*).

STEBBING, E. P. . . A further Note on the Preservation of Bamboos from the attacks of the bamboo beetles or shot-borers, *Indian Forester, xxxi, 249.*

STEBBING, E. P. . . A Note on the Quetta-borer (*Æolesthes sartus*).

STEBBING, E. P. . . An invasion of Scolytidæ in the Vosges, *Indian Forester, xxxi, 395.*

STEBBING, E. P. . . On the Cecidomyid (Cecidomyia sp.) forming the galls or pseudocones on Pinus longifolia, *Indian Forester, xxxi, No. 429.*

STEBBING, E. P. . . A Note on the Chilgoza (*Pinus Gerardiana*) bark-boring beetles of Zhob, Baluchistan.

STEBBING, E. P. . . On the life-history of Termes (Coptotermes) Gestori, the Hevea rubber termite, *Indian Forester, xxxii, No. 110.*

STEBBING, E. P. . . A visit to some European Schools of Forestry.

STEBBING, E. P. . . A Note on the life-history of *Hoplocerambyx spinicornis*, the Singbhum Sal-borer.

STEBBING, E. P. . . Departmental Notes on Insects that affect Forestry.

VETERINARY SCIENCE.

BY

A. LINGARD, M.B., M.S., D.P.H.
Imperial Bacteriologist.

Sero-therapy.

1. Further progress has been made during the year 1905-06 in increasing the utility of the Muktesar Laboratory. Extended accommodation for increased number of animals has been approved of and buildings for the preparation of tetanus-antitoxin, mallein, and charbon symptomatique serum have been sanctioned.

2. The following table will show at a glance the increment both in output and issue of different products during the past twelve months :—

Name of sera.	Quantity prepared.	Quantity issued.	Increased manufacture as compared with last year.	Remarks.
	Doses.	Doses.	Doses.	
Anti-Rinderpest serum .	211,407	204,979	59,552	
Anti-Anthrax serum . .	44,862	26,712	17,391	
Hæmorrhagic Septicæmia serum.	15,470	18,603 *	12,335	* Out of 3,135 doses manufactured during 1904-05.
Mallein	3,407	2,584	1,893	

In addition a large number of doses of various forms of vaccines and serum for the protection of animals against charbon symptomatique were prepared, the efficacy of which is now being tested in the field.

3. The number of animals immunized with serum treatment during the past twelve months and the mortality amongst the injected animals are shown in the following statement:—

Name of disease.	Number of outbreaks successfully dealt with.	Number of animals injected.	Number of deaths in inoculated animals.	Per cent. of mortality.
Rinderpest . . .	910	124,015	383	0·37
Anthrax	248	25,910	72	0·26
Hæmorrhagic Septicæmia .	125	13,451	14	0·11

It must be noted that the number of different outbreaks successfully dealt with is of greater importance than the number of animals injected, because, as soon as an outbreak is discovered, the whole of the affected and contact animals are injected with serum, or a cordon of protected cattle is formed round the primary focus of the disease and its further progress stopped.

Training of Officers and Veterinary Assistants.—Four officers of the Army Veterinary Department attended 60 lectures and practical classes daily in two courses during the months of June to September, each course lasting for two months, and in addition 61 Veterinary assistants were trained in various methods of inoculation and serum therapeutics.

Examination of Specimens.—The result of examination of 101 specimens containing in some instances several different objects (for examination) was communicated, after the shortest possible interval, to the respective officers interested.

BACTERIOLOGY.

Rinderpest.—During the past year, the potency of the anti-rinderpest serum produced at this laboratory has been considerably enhanced. In previous years it was prepared by mixing together three-and-a-half parts of the serum of plains animals with one of that of hills. Now, however, it has been found that a more economical, useful, and convenient dose can be prepared by mixing in the proportion of 2 to 1.

Experiments were conducted with a view to determine the protective value of various anti-rinderpest sera, prepared by hyperimmunizing

different breeds of cattle with virulent blood obtained from the same and other breeds, after allowing periods varying from $5\frac{1}{2}$ to 6 years to elapse, during which intervals the sera were deposited at Muktesar.

It was found that—

(i) Plains animals hyperimmunized with virulent hill blood, the serum lost 33 per cent. of its protective value in six years.

(ii) Hill bulls hyperimmunized with virulent hill blood, the serum retained its previous protective power after six years.

(iii) Buffaloes hyperimmunized with virulent buffalo blood, the serum had lost none of its protective power in six years.

It will be seen, therefore, that a higher protective serum results from hyperimmunizing an animal with virulent blood from the same species.

Experiments, conducted with a quantity of serum No. XXII which had been kept for a year in the Central Provinces in a pit 10 feet in depth, the temperature of which is said to have never exceeded 90° F., prove that the serum lost little of its protective power.

Rinderpest in Black Buck.—Experiments conducted on a black buck show that this species of antelope is liable to be affected by rinderpest, also that the causal agent of rinderpest loses its high degree of virulence for hill bulls, the most susceptible breed of cattle in India, by passage through the black buck.

Piroplasmosis.—Work has been continued with this disease and it has been ascertained that 50 per cent. or more plains bulls and the majority of hill bulls at the laboratory are the subjects of piroplasma in one form or other. A separate report will be issued dealing with this disease ; as it would occupy too much space and require coloured plates to illustrate the paper, it is held over.

Piroplasmosis in the Horse.—Several points of interest with regard to equine piroplasmosis in this country may be mentioned as bearing out observations made in other countries, especially in South Africa. In the disease known as *Bilious fever* in India, the causal agent, as has been long recognized, is a piroplasma. This organism in the blood of equines exhibits various forms—globular, pyriform, and spindle-shaped; but the characteristic which immediately draws one's attention in stained microscopical specimens of blood is the fact that the organisms are frequently found in fours, in the form of a cross in the same red

corpuscle. One can trace the division of a piroplasma into four individuals—and later the assumption of the cross form—while in others they exceedingly resemble the screw of a steamer, for the four parasites which make up the cross form, each exhibit a curve similar to that observed on the individual flanges of a screw of a steamer.

This would more or less point to the fact that *in vivo* such an endoglobular organism presents a rotatory motion from left to right.

Trypanosomiasis.—

Surra.—Equines, bovines, antelope, camel.

Dourine.—Equines, antelope (black buck).

Under the above heading are included spontaneous forms of disease, occurring in various species of animals, the causal agent of which is respectively a trypanosoma. The comprehensive term surra has been used to designate certain forms of disease common to this country which attack equines, camels, bovines, and antelopes.

Research has, however, brought to light several different species of trypanosomata as being the "materies morbi" in the various diseases of animals above mentioned.

Dourine or *Mal de coit* is of course due to a flagellate long recognized and known by the name of *T. Equiperdum.*

In the following account a short summary will be given concerning the results arrived at with the various trypanosomata met with. It must be recognized that it is necessary that advantage be taken to investigate various forms of oganisms whenever they happen to present themselves, for it is impossible to say when and where a further opportunity may present itself, except in the case of the more common forms of diseases.

Equine Surra (*T. Evansi*).—*To attenuate by passing through the body of animals.*—This question has been dealt with in a paper already published by me in the Journal of Tropical Veterinary Science, and the results of further experiments under investigation will be recorded in due course when they are concluded. Experiments with the trypanosoma of spontaneous equine and spontaneous camel surra by repeated passages through rats and mice respectively were initiated in April 1906. These experiments were undertaken with a view to determine whether a less virulent form of the disease could be brought about, and any immunity conferred thereby when equines are inoculated with the blood of the small rodents after at least 100

passages have been made. Up to the present the following passages have been carried out, namely :—

Equine	. . . .	. 44	passages through the rat.	
Do.	. . . .	. 43	„ „ „	mouse.
Camel	. . . .	. 40	„ „ „	rat.

It will, therefore, be necessary for a considerable period to elapse before one can come to any conclusion with regard to the results obtained.

By the administration of certain chemicals.—The experiments mentioned in my last year's report, with a view to destroy the causal factor of equine trypanosomiasis by the administration of certain chemicals, was continued during the past year. Arsenic in combination with a colouring material designated Trypanrot by Ehrlich, who introduced it to the scientific public, was employed.

Trypanrot is prepared by bringing about the combination of one molecule of Tetrazotierter Benzidinmonousulfosäure and two molecules of Naphthylamindisulfosäuren Natrium.

The lethal dose of arsenic (1 in 500) for equines, when injected intravenously, was found to be about 0·0033 grammes per kilo. body weight, when two-thirds of the above amount, 0·0022 grammes, were administered under similar conditions, recovery took place, although, occasionally, symptoms of severe colic were exhibited by the injected animals. Trypanrot was injected at first in a four per cent. solution, but in some cases in equines this amount was not well tolerated, and was later reduced to two per cent. As this latter amount proved to be totally insufficient for the purpose for which it was used, the amount was gradually increased again to a maximum of 3·3 per cent. in other cases of equine disease.

At present the solution as utilized by us is composed as follows :—

		Grammes.
Acidium Arseniosum Sodii Carbonas	āā	1·0
Trypanrot		16·5
Aq. distillata		500·0

We inject intravenously and slowly (the solution being previously heated to a little in excess of the normal temperature of the blood), in C. C., half the body weight of the horse in pounds. So that a 500-lb.

horse would receive 250 C. C. of the above solution, equivalent to 0·5 grammes of arsenic and 8·25 grammes of trypanrot.

Of five country-bred ponies, the subjects of inoculated equine surra, two recovered after treatment with arsenic and trypanrot. One of these animals had exhibited flagellates in its blood, numerous to swarming, for twelve consecutive days previous to the commencement of the intravenous injection of the solution, and a successful termination was not anticipated. A further successful case was that of a donkey.

Pony No. 47, body weight 300 lbs. or 136·37 kilos., received intravenously 0·0022 grammes of arsenic per kilo., or 150 C. C. of a solution, and 0·044 grammes per kilo. of trypanrot, so that the animal received arsenic 0·3 grammes, and trypanrot 6·0 grammes.

Pony No. 205, body weight 475 lbs. or 215·90 kilos., was injected intravenously with 237·6 C. C. of an arsenic and trypanrot solution containing 2 per cent. of the latter, so that the dose of arsenic utilized was 0·475 grammes, while 8·636 grammes of trypanrot were injected.

The donkey also, the subject of surra, body weight 140 lbs. or 63·3 kilos., received only 14·06 C. C. of arsenic and trypanrot (4 per cent.).

Death followed in the unsuccessful cases in ponies in 130, 134, and 191 days, respectively. It is of interest to note that of 29 surra equines untreated, 23 succumbed within the first 30 days of the disease, and in six only the course of the malady was prolonged from 31 to 87 days. So that the lives of the ponies unsuccessfully treated were much prolonged by the use of the chemicals in combination. Aged Australian horses, the subjects of equine surra, treated by the above method, with doses according to their body weight, succumbed in 36 and 38 days, the flagellates being absent from the peripheral blood for periods of but 20 and 30 days, respectively.

It has been observed that the best time to inject arsenic and trypanrot intravenously is not when the trypanosoma is present in large numbers in the peripheral blood of the animal, for then the toxin present in varying quantities appears to act with the chemicals introduced and together they produce rapidly fatal results. It has been demonstrated by practical experience that the best effects are produced when arsenic in combination with trypanrot is introduced intravenously on the first day of a paroxysm of surra, when the toxin has been in whole or in greater part eliminated from the system of

the animal, and this has allowed of the flagellate re-appearing in small numbers in the blood of the peripheral circulation.

To attenuate the trypanosomata by means of cultures.—These experiments have been largely augmented during the past year, full advantage having been taken of all the new and improved media worked out by other observers in various parts of the world, but especially by Novy and McNeal, the originators of this line of research. Our experiments have not been as successful as could be desired. When, however, we compare the results which McNeal has recorded together with his failures, we have no cause to lose heart at our own results, for the above-mentioned investigators recorded "fifty independent series of culture trials had to be made by them before they could duplicate the last positive results."

Camel Surra.—*Attenuation of the trypanosoma of spontaneous camel disease before testing on equines.*—Some of the most important results arrived at bearing on this question have been dealt with in an article published elsewhere, so it will be unnecessary to recapitulate the same.

A fairly comprehensive report on camel trypanosomiasis, the collected results of experiments which have now been in course of investigation during a period of four years, with special reference to the life-history of the causal factor, has been almost completed and will be published at the first opportunity.

The report amongst other questions will deal with :—

(i) Spontaneous camel trypanosomiasis.

(ii) Spontaneous disease in camels carried through the agency of flies *Tabanidæ*.

(iii) Spontaneous disease inoculated subcutaneously into a second animal of the same species.

(iv) Healthy camels inoculated with equine trypanosomiasis.

(v) Animals inoculated intravenously or subcutaneously with infective blood from spontaneous trypanosomes in camels.

(vi) Equines inoculated with the blood of camels, at different periods in the course of the malady.

(vii) Intravenous injection of a healthy equine with a quantity of normal camel serum, and subsequent inoculation with the *T. Evansi*.

(viii) Intravenous injection of a healthy equine with blood serum drawn from a surra camel 44 months after the disease had been spontaneously contracted—subcutaneous inoculation of *T. Evansi* within a short interval.

(ix) Simultaneous inoculation of equines on different sides of the body with equine and camel surra blood respectively.

(x) Healthy animals (equines) inoculated subcutaneously with infective blood from bovines and buffaloes, the subjects of inoculated camel trypanosomiasis.

(xi) Is camel blood infective several years (44 months) after the date of the primary attack of spontaneous trypanosomiasis, when the flagellate forms have not been observed in the peripheral blood for several months ?

(xii) Are the causal agents of equine and camel trypanosomiasis due to one and the same species of flagellate, *viz.*, *T. Evansi ?* Is any immunity conferred upon a buffalo against equine surra when the animal has been previously inoculated and has just passed through an attack of camel trypanosomiasis ?

By the administration of certain chemicals.—Although as early as 1893 I recommended arsenic in the form of Liq. Arsenicalis to be administered to horses and camels, the subjects of trypanosomiasis, mixed with their food, and this form of treatment proved to be of value in some cases, no knowledge of any kind was forthcoming with regard to the tolerance or otherwise of camels to the subcutaneous or intravenous injection of arsenic in solution alone or in combination with trypanrot.

Therefore our first care was to make experimental researches for the elucidation of these problems.

The doses of arsenic and trypanrot well tolerated by equines in this country, when injected intravenously, in combination, have been proved to be lethal to camels in the course of a few hours. Camels appear to be very susceptible to the action of arsenic and trypanrot in combination, as colic followed small doses intravenously. Two-thirds of the doses administered to equines was tolerated by camels, and produced no severe symptoms, but such doses only kept the flagellates in check for varying short periods, when they again appeared in the peripheral blood in increased numbers and death followed.

A new form of organism in camels.—A new form of organism has been discovered in the erythrocytes of some camels suffering from spontaneous trypanosomiasis. Specimens were forwarded to Regierungsrath Fitz Schaudinn for favour of identification, but the untimely decease of that great savant has rendered it impossible to obtain further help from that master mind. The organism in the red blood corpuscles of the camel presents the appearance of a long thread, one extremity terminating in a small protruberance or knob. Individually the length varies from 25 μ to 26·25 μ. The organism may be observed at one stage of development following the exact contour of a red blood cell, while in another it forms a figure of eight in the interior of such cell, or projects half in length from it. Less seldom the organism may be discovered lying free in the blood plasma.

Trypanosomiasis in Antelopes.—With a view to determine whether black buck are capable of conveying the *T. Evansi* in their blood for long periods, as in the case of bovines, and thus being able, through the agency of flies, to disseminate the disease to other susceptible animals, three black buck were respectively inoculated with varying amounts of blood taken from Control surra equines, the one which received 0·2 C. C. subcutaneously exhibited an incubation period of three and-a-half days and succumbed on the third day of the malady, with over one hundred trypanosomata in each field of the microscope (Leitz· Oc. 4. Obj. VII), maximum temperature 39·9° C., only 0·9° C. above the normal of health. The second animal pricked once only, with the finest needle of a Pravatz syringe (1 C. C. capacity) detached from the body of the instrument, containing a trace of a drop of spontaneous equine surra blood, hæmatozoa 17 in a field of the microscope, succumbed to an acute septicæmia, the blood of the peripheral circulation at the time of death containing enormous numbers of bipolar staining cocco-bacilli.

The third animal was also but once pricked with a small needle detached from the Pravatz syringe in the skin of the back. In this instance, the contained surra blood presented seven flagellates in a field of the microscope. The incubation period occupied four and-a-half days. Two paroxysms occurred, lasting 12 and 15 days respectively, and two intermissions of three and ten days, death taking place on the first day of the third paroxysm with one flagellate in 25 fields of the microscope. Course of disease 41 days.

From the above experiments one may draw certain deductions :—

(i) That all black bucks do not exhibit the same degree of susceptibility to *T. Evansi.*

(ii) That toxin is not readily elaborated, for the trypanosoma swarming between 60 and 100 in each field for six consecutive days in No. III buck, without making any appreciable difference on the number of flagellates in the peripheral circulation, until the termination of that period.

(iii) That the buck is incapable of carrying over the trypanosoma *Evansi* from a spontaneous equine source, from the end of one surra season to another.

(iv) That this species of deer is highly susceptible to hæmorrhagic septicæmia (wild-seuche).

Dourine.—In March 1904, I submitted to Government a report on dourine or *Mal de coit* in different breeds of equines in this country, but unfortunately at that time was unable to arrange for an account of the various nervous lesions found in chronic cases of this disease. At a later date, I was fortunate enough to enlist the interests of a neuropathologist of European renown—Dr. F. W. Mott, F.R.S., Pathologist to the London County Asylums—who acceded to my request to investigate the nervous tissues in dourine.

Accordingly the tissues of the central nervous system, including the posterior spinal ganglia and attached roots from an Arab stallion, the subject of chronic dourine, were forwarded to Dr. Mott for examination.

The animal in question, Monarch, age 5½ years, 14—1½ hands acquired dourine between the 4th to 6th May 1903. It exhibited 156 cutaneous plaques, and repeated eruptions of a disseminated form of urticaria, which latter persisted on several occasions for long periods together with marked symptoms of paraplegia, and died August 15th, 1905, twenty-seven and-a-half months after the infective coitus.

The following description of histological changes in dourine appeared in a paper submitted by Dr. F. W. Mott, F.R.S., to the Royal Society in February, and read March 8th, 1906, entitled "The Microscopical Changes in the Nervous System in a Case of Chronic Dourine or *Mal de coit*, and comparison of the same with those found in Sleeping Sickness." The full paper will be found in the Proceedings of the Royal Society, No. B. 522, July 23rd, 1906.

Description of Histological Changes in Dourine.—Throughout the grey matter of the spinal cord the ganglion cells show marked chromolytic changes and the vessels exhibit evidence of chronic inflammation with scattered capillary hæmorrhages.

The small vessels show lymphocyte infiltration around, but there is nothing resembling the marked perivascular lymphatic infiltration met with throughout the grey matter in all cases of well-marked sleeping sickness. The ganglion cells for the most part retain their normal outlines, but are stained a uniform bluish purple with a badly defined and imperfectly stained pattern of Nissl granules. The most marked change is observed in the lumbar region.

Sections of the lumbo-sacral cord with attached roots, after embedding in celloidin and staining with Van Gieson's fluid and by Weigert method, exhibited the following changes. The roots, anterior and posterior, are infiltrated with lymphocytes, also all the vessels are surrounded and their walls infiltrated with small round cells. The connective tissue, septa, carrying the vessels as well as the perineurion and endoneurion, are thickened and infiltrated with lymphocytes, also the loose connective tissue outside the dura mater; the dura mater itself and the vessels and tissues in the subdural space show signs of inflammation.

The condition simulates an acute syphilitic meningitis in many ways, except that I can discover only occasional evidence of an obliterative arteritis.

Some of the larger roots seen in the section are very markedly affected by the inflammatory process. These are judged to be posterior roots, because a posterior spinal ganglion cell can be seen here and there in them; moreover, they occupy among the roots a posterior position. The capsules of the ganglion cells that are seen are crowded with lymphocytes presenting an appearance like that observed in sleeping sickness. Some of these roots in transection under a high power show the nerve fibres to have been destroyed and their place occupied by proliferated branching neurilemmal connective tissue cells lying in the the centre of an oval or circular space bounded by highly vascular, thickened, and swollen and amorphous endoneurion. In the centre of most of these cells is a highly refractive round or oval space.

Throughout the spinal cord, but especially at the lumbo-sacral and cervical enlargements, there is a marked thickening of the subpial

network of the glia tissue which extends into the white substance along the main septa and branches.

At the periphery, the proliferated glia tissue consists mainly of a dense reticulum of fibrils, but in the substance of the white matter great numbers of large branching neuroglia cells are seen sending their processes in all directions. On careful examination of the longitudinal and transverse sections, these proliferated neuroglia cells, which are often spoken of as mesoglia cells, can be seen to send their processes to end like a foot upon the wall of a small vessel. This overgrowth of glia tissue is seen throughout the white matter of the spinal cord, whatever region is examined, but more especially in the lumbar and cervical enlargements, especially the former. It is more obvious in the posterior columns than elsewhere, especially along the median fissure and in the root zone. It does not wholly correspond to system tracts of fibres which have undergone degeneration, but appears (except in the root zone of the posterior column) to be a chronic formative proliferation of the glia tissue caused by an irritant, entering the lymphatics and subarachnoid space. The posterior column is much more affected than the rest of the white matter.

In the lumbo-sacral region, there are three definite zones of degeneration in the posterior column, no doubt corresponding to the destroyed roots. The lymphocyte infiltration is observed around the small vessels, and numerous lymphocytes are scattered about in the septa in the white matter. In the roots a well-marked perivascular infiltration with lymphocytes can be seen and some hæmorrhages in the lumbar region.

The chronic interstitial inflammation of the anterior roots, in which all the nerve fibres appear to be normal, together with the fact that there is subpial proliferation of the glia tissue of the lumbo-sacral and cervical enlargements in their entire circumference, with extension of the same along the septa, shows that this proliferation of the connective tissue supporting structure, whether of the undamaged roots or the spinal cord, is not due to atrophy of the nervous elements, although in the posterior columns, where there are three definite bands of sclerosis, the neuroglial proliferation is without doubt secondary to neural destruction. Occasional foci of micro-organisms are seen, but do not play any part in the chronic changes above described. They are not found in the blood or inflammatory exudations.

In none of the sections could I find any trypanosomes stained by the various methods, which we know will show them, if they are present in any numbers.

Sections of the posterior spinal ganglia and attached roots in the cervical, upper dorsal, mid-dorsal, lower dorsal, and lumbo-sacral regions have been examined by the methods previously described and the appearances compared with those observed in sleeping sickness.

In all these ganglia there was evidence of intense chronic inflammation with marked proliferation of the endothelial nuclei of the capsule and lymphatics, together with lymphocyte infiltration of the interstitial fibrous tissue, and this morbid change can be followed from the nerves to the ganglion and along the posterior roots. This change is most marked in the lower dorsal and lumbo-sacral ganglia, and where the chronic inflammation is most intense, there the posterior spinal ganglion cells are most affected.

In all the sections some of the ganglion cells have undergone vacuolar degeneration, and even complete destruction, their place being occupied by inflammatory products, but the neuronic destruction is most marked in the lumbar region, which is the situation, as before remarked, of extensive posterior root destruction and system-degenerative sclerosis of the posterior columns.

Both these conditions are the outcome of the destruction of the posterior spinal ganglion cells. But this destruction must also have led to destruction of the peripheral branch of the T-shaped process of the ganglion cells, and this would give rise to a sensory polyneuritis. Unfortunately, I have not had forwarded to me any of the nerves to examine.

However, the comparatively normal appearance of the anterior roots, and the very complete destruction of many of the sensory roots, together with the well-marked sclerosis of the posterior columns, would suggest that this animal may have suffered with a sensory paralysis of the hind limbs analogous to tabes dorsalis, rather than a polyneuritis.

An argument in favour of this hypothesis is that in severe alcoholic and other forms of polyneuritis the motor anterior horn cells usually show characteristic degenerative changes which are not seen in the spinal cord of this animal.

Now it has been shown by numerous authorities, but especially in a very systematic manner by Head and Campbell, that herpes zoster is caused by an inflammation of the posterior spinal ganglia, the seat of the eruption depending upon the particular segmental ganglion or ganglia affected. It is, therefore, reasonable to associate the eruption of the characteristic cutaneous plaques with the inflammatory irritation of the ganglia as they become successively affected by the noxious agent.

Both Lingard and Laveran remark upon the curious nature of the eruption; the former believes it to be an angio-neurotic œdema which occurs in the form of circular plaques, as if a ring had been introduced under the skin.

They remark that although trypanosomes can only be found in the blood with difficulty, yet they are always present in the fluid which can be drawn from a plaque. Lingard concludes, therefore, that embolism by trypanosomes is the cause, but if there is angio-neurotic œdema occasioned by the irritation of the posterior spinal ganglia, then it is possible that in the blood or with inflammatory exudation the trypanosomes may find suitable conditions for multiplying by fission. The theory, which I have advanced for the origin of the rash, finds some support, moreover, in experiment, for Dr. Bayliss has shown that stimulation of the posterior roots produces vaso-dilatation. Again, these plaques often leave patches of leucoplacia, which may be due to neurotrophic causes associated with the destruction of numbers of the spinal ganglion cell neurotrophic centres. In chronic trypanosome infections by *T. Gambiense*, even before the lethargy occurs, outbursts of irritative papules or other skin eruptions occur, and they might be accounted for by irritation of the neurotrophic centres in the spinal ganglia. The changes in the ganglia are never so intense as in dourine, but I have now examined quite a number of posterior spinal ganglia in sleeping sickness cases, and I have never failed to find some change, never sufficient, however, to produce cell destruction, such as is found in dourine. The most intense change I have met with is shown in the photo-micrographs, and this in no way differs, except in degree, from that seen in dourine. Laveran and Mesnil mention that dislocation and fractures may occur in dourine, and we know that spontaneous dislocation and fractures are met with in tabes dorsalis, a disease in which the posterior roots and posterior columns of the spinal cord undergo degenerative atrophy.

The membranes at the base of the brain of this animal, which died of dourine, seemed thicker than normal.

On microscopical examination, sections of the peduncles and interpeduncular structures exhibited a subpial and septal neuroglia proliferation very similar to that seen in the lumbar region of the spinal cord. I observed, however, but little or no lymphocyte infiltration.

Conclusions.—The more chronic the case of trypanosoma infection, the more extensive is the glia cell proliferation. The overgrowth of glia tissue is manifested by an increase in number and size of cell fibrils. Many large cells are seen with branching processes, sending one process to form a foot on the vessel wall, others are seen entering into the formation of a dense reticulum in the perivascular lymphatic space. Normally, the perivascular spaces have only a few delicate septa passing across which could not in any way impede the flow of the cerebro-spinal fluid and lymphocytes.

Dr. Eisath, working in my laboratory, has recently shown by a differential method of staining that a large number of the round cellular elements contained in the perivascular infiltration of chronic sleeping sickness are not lymphocytes, but the nuclei of neuroglia cells. I have not found this glial proliferation in acute cases of trypanosome disease in animals, only in the chronic case of dourine, and in the two cases of experimental sleeping sickness in monkeys.

The glial proliferation in these cases is in excess of, and appears to precede the perivascular lymphocyte accumulation so constantly found in human sleeping sickness, which we now know may be a very chronic disease. Moreover, in most cases of uncomplicated human sleeping sickness, there is in the spinal cord a universal proliferation of the glia tissue extending along the subpial septa and vessels, without apparently destroying the nerve fibres. It is possible, therefore, that the lymphocyte accumulation in the perivascular lymphatics does not occur until the neuroglia proliferation has become advanced, and this may account for the fact that lepto-meningeal perivascular infiltration with lymphocytes (so-called chronic meningo-encephalitis) is not met with in the nervous tissues of animals inoculated with various trypanosomes, that die within a comparatively short time, either from exhaustion or from the poisonous effects of the infection upon the cells of the nervous system or from secondary microbial invasion.

Greig concludes from his experiments that the onset of the symptoms of sleeping sickness synchronise with the entrance of the trypanosomes into the lymph spaces of the nervous system, and this is accompanied by an increase of lymphocytes in the cerebro-spinal fluid. Whether it be as Greig's experiment suggest, that the continuous presence of the trypanosomes in the cerebro-spinal fluid acts as a direct cause of irritation of the lymphatic structures of the central nervous system, or whether it be the result of the absorption of toxic products from the multiplication of the trypanosomes in the lymphatic glands, or whether it be the extension of a chronic inflammatory process from the paravetebral glands along the lymphatics of the vessels and nerves proceeding to the cerebro-spinal axis, as seems probable in dourine, one fact is certain, and that is, the symptoms of sleeping sickness are associated with and the depth of the lethargy and chronicity of the disease is in great measure proportioned to the extent and degree of leptomeningeal, septal, and perivascular lymphatic cell proliferation. This cell proliferation is made up partly by an overgrowth both in number and size of the neuroglial cells to form a dense meshwork and partly of accumulated entangled and occasionally altered lymphocytes. In proportion to this chronic lymphatic inflammation the neural elements display relatively slight degenerative changes in cases uncomplicated by microbial infection, thus differing from dourine where there was very obvious degeneration of posterior ganglion cells and roots with corresponding degeneration in the posterior column. The mind of a patient suffering with sleeping sickness remains clear usually until near the end. He can easily be aroused from his lethargy, and comprehends what is said to him, replying in a slow sleepy manner, and with manifest disinclination to continue a conversation or to exercise any mental or bodily effort. These symptoms point to a functional depression of the anatomical basis of the seat of consciousness rather than to a widespread destruction as in general paralysis of the insane. This functional depression of the neural elements may be accounted for by (*a*) increased intercranial pressure brought about by a retardation of lymph circulation and the cell proliferation; (*b*) the interierence with the blood circulation, and with the gaseous and metabolic exchanges between the blood and the lymph, and between the lymph and the neurone; (*c*) in chronic cases by a certain amount of neurone destruction as shown by

Marchi's degeneration of fibres, and a certain amount of cell and fibre destruction.

Spontaneous Trypanosomiasis in Bovines.—Between the years 1890—1894, during which period investigations were conducted at Poona, certain large forms of trypanosomata were discovered in the blood of plains bovines, the most notable species designated *T. Giganteus*, together with a long and active form, the undulating membrane of which was particularly well developed. During 1894, two other forms were observed in the blood of working bullocks in the Mohan Pass, during an outbreak of equine surra, when some 80 animals succumbed to the disease.

These bullocks exhibited (i) a long thin and (ii) a small form concurrently present in the blood of the peripheral circulation, but the further history of the animals could not be ascertained.

Again in the South Punjab, during the cold season of 1895, an outbreak of surra occurred amongst horses in the Kurnal Remount Depôt: here also a considerable number succumbed to the malady. Concurrently with this epizootic, several large working bullocks on the estate were found to be the hosts of flagellate organisms, and again (i) a long broad and (ii) a smaller variety were demonstrated in the peripheral blood, but a dog subcutaneously inoculated with 1·25 C. C. of the blood of one of the above-mentioned animals presented the smaller trypanosoma only in its circulation and succumbed after exhibiting all the usual symptoms in a period of 94 days.

Hill bovines are small in comparison to plains, and it was only in the year 1902 that the first species of trypanosomata was discovered by me in the peripheral circulation of a hill bull which had succumbed to inoculated anthrax at Muktesar. This species of trypanosoma was designated the *T. Himalayanum.*

Since the above date, Durrant and Holmes have described a species of trypanosoma in hill cattle, which it is believed may be similar to the larger one observed by me in plains cattle in Poona and in the Mohan Pass, during October 1892 and 1894, respectively. Until the present year it has not been possible to discover bovines which presented only the small forms of trypanosomata in their blood. During 1906, however, certain hill bovines hyperimmunized with virulent rinderpest blood, after passing through the usual thermal reaction, exhibited some days later a second thermal reaction, not to be accounted for unless

caused by a secondary infection due to the presence of a species of piroplasma or a trypanosoma.

On microscopical examination of the blood, the second surmise was found to be correct, for the blood contained large numbers of a small form of flagellate resembling only the *T. Evansi*, the causal factor of spontaneous equine and perhaps spontaneous camel surra.

The hill bulls in question were brought straight from the valleys close to the snow mountains, and as far as we are able to judge had not been exposed to the bites of flies which had been in contact with surra animals, except in the submontane tracts from which they were purchased.

It was found impossible to absolutely determine whether the trypanosoma was present in the affected animals previous to being injected or whether the causal factor of the disease was conveyed respectively at the time of the injection with the massive doses of rinderpest blood.

Animals inoculated with infective blood.—Two hill bulls inoculated with 7·0 C. C. of blood intravenously, after an incubation period of five and-a-half days, respectively, both exhibited the organisms in their peripheral circulation and one animal succumbed suddenly to a cerebral hæmorrhage with a considerable amount of blood extravasated over the superior and external surfaces of the right cerebral hemisphere. The second animal after passing through two short paroxysms of the disease, lasting four and six days respectively, has shown no further symptoms of the malady, although a period of over ninety-five days has elapsed since the last appearance of the flagellate in the blood.

A plains bull, tested in a similar manner to the two previously mentioned, passed through two paroxysms and the organism has not been since observed, on examination of the blood, during a period of over eighty days. On the other hand, a buffalo inoculated with 5 C. C. of blood intravenously on the 5th July, has passed through six paroxysms lasting twenty-eight days and five intermissions occupying thirty-eight days.

An Australian and a country-bred horse succumbed in forty-five and fifty-seven days, respectively. In the former case the action of the trypanosoma approximated more to the *T. Brucei* rather than to the *T. Evansi*, in that the course of the disease was marked by one paroxysm only, as is sometimes observed in the mountain districts, in

this country, when surra is passed through from equine to equine. A donkey inoculated at the same time as the horses exhibited ten paroxysms lasting seventy-three days, and has arrived at the 104th day of disease without presenting any symptoms of emaciation.*

Of the results obtained by inoculation with other species of animals, the following is a summary:—

Two monkeys, each inoculated subcutaneously with 1·0 C. C. of infective hill blood, succumbed in thirty-four and forty-five days.

Two pariah dogs in twelve and fourteen days.

Two rabbits in twelve and fifty-nine days.

Two guineapigs in seventy-nine and one hundred days.

Four rats (white) in two, three, three, and eight days, and four mice in three, four, and four days, respectively.

The fourth mouse exhibited trypanosomata in the blood for three days, but during a further period of 106 days the organism has been absent.

Measurements, etc.—With regard to the dimensions of the trypanosomata, the causal factor of this form of spontaneous disease in hill bulls, it has been found that during a paroxysm lasting five days in all when the mean measurements of a large number of flagellates on each day of the period in question have been made, the trypanosomata gradually increased in length until the organisms had been swarming in the blood for a period of twenty-four hours; they then during the following two days decreased in length. The mean measurements were as follows:—

1st day	26·77μ
2nd „	29·35μ
3rd „	30·36μ
4th „	28·81μ
5th „	27·35μ

* This animal succumbed after a course of disease lasting 158 days.

The maximum, minimum, and the mean measurements of the flagellates are given below, together with the percentage of the mean:—

	Length from posterior extremity of trypanosoma to the centre of the blepharoplast.	Length from centre of blepharoplast to posterior edge of nutritive nucleus.	Postero anterior length of nutritive nucleus.	Length from anterior edge of nutritive nucleus to termination of body protoplasm anteriorly.	Length of free flagellum.	Total length of trypanosoma.	Maximum width of body.
	I μ	II μ	III μ	IV μ	V μ	VI μ	VII μ
Maximum . . .	3·28	9·02	3·28	16·40	3·28	35·26	1·64
Minimum	0·00	4·92	2·95	8·20	3·28	19·35	1·31
Mean of 80 trypanosomata .	2·03	7·30	2·55	11·64	4·29	27·85	1·65
Percentage of the mean .	7·38	26·24	9·16	41·80	15·20	100·00	5·93

Now if we compare this last percentage with that obtained from the mean of 126 trypanosomata (*T. Evansi*) in spontaneous equine trypanosomiasis we find the following:—

	I	II	III	IV	V	VI	VII
Percentage of the mean of 126 trypanosomata.	6·82	28·31	11·87	39·85	13·15	100·00	6·14

These figures, however, are those found in the horse and may not coincide with those as observed in spontaneous bull trypanosomiasis; it is therefore necessary for comparison that the measurements of *T. Evansi* should only bemade use of after having been passed through the hill bull. Let us therefore take the figures representing the mean percentage under these latter conditions, which are as follows:—

T. Evansi through Hill Bull.

	I	II	III	IV	V	VI	VII
Percentage of mean of 85 trypanosomata.	7·48	26·39	8·58	42·83	14·72	100·00	5·50

On comparison of these with those obtained from a large number of observations after passage of the *T. Evansi* through the hill bull, we find that the figures are almost identical in each case, and there is every likelihood that the trypanosoma discovered in spontaneous disease in bovines and the *T. Evansi* of spontaneous equine disease are identical. We must, however, take into consideration the results of inoculation of large and small animals with the two forms of flagellates, the *T. Evansi* and the bovine trypanosoma. All the various animals, both large and small, have succumbed within a period of three and-a-half months, with the exception of a buffalo, which is still alive and in perfect health; one white mouse * has also proved more or less refractory to the disease. Similar species of animals inoculated with spontaneous equine surra at an elevation of 7,500 feet have taken as long as 140 and 92 days, respectively, to run through the course of the malady; consequently, the full time has not yet elapsed. Bovines have never been known to succumb as a result of experimental inoculation when inoculated with infective surra blood. Our present researches, however, proved that in one case of four bovines inoculated the animal succumbed to cerebral hæmorrhage on the fifth day of the disease, death coming about suddenly, a form not previously observed in bovines in this country, although a percentage of bovines in South Africa are said to die from Nagana.

It would, therefore, appear that in India bovines may contract and harbour a trypanosoma in their circulations very much resembling in characteristics the *T. Evansi* of spontaneous equine surra, and when the first paroxysm has been passed through, may, in a majority of cases, fail to exhibit any further symptoms. These animals may be transferred to long distances or to other countries where the bovines and other animals, equines, etc., are highly susceptible. Through the agency of flies the disease may be conveyed from the emigrant to the indigenous cattle in the new home of the former. For, as the newly introduced bovines harbour in their blood for long periods the trypanosoma in its immature form and at intervals the mature form of the flagellates, so a terrible calamity may be the result.

* This mouse died after an intermission of 106 days. A rat inoculated with blood from this mouse at time of death exhibited the trypanosoma after an incubation period of 13 days.

An instance within recent years occurred in Mauritius when Indian cattle were landed and allowed to mix with the animals on the island.

The above account deals with only one new form of trypanosomiasis in bovines.

It is my intention, however, to publish a paper during January 1907, containing a description of other forms of flagellates discovered in the circulation of plains and hill cattle, respectively, with special reference to trypanosomic forms which have up to the present not been described.

Spirillum in the blood of Hill Bovines.—In the peripheral blood of hill cattle brought to Bareilly during the autumn of 1905, well-developed spirilla were discovered, resembling somewhat the organisms of relapsing fever in man. The mean length of each organism, pointed at either extremity, was 19μ, and was composed of nine spirals; each organism, however, showed a small area in its middle unstained, evidently the seat of division at a later date of development.—

(i) It was found impossible to convey the spirillum by subcutaneous inoculation of blood either to monkeys or other small animals.

(ii) That this spirillum, although probably conveyed by a species of tick, could not be detected in the body tissues of the ticks removed from the host.

(iii) That emulsion of ticks removed from the sick bull did not reproduce the disease on subcutaneous inoculation into healthy animals.

New species of sporozoon.—A new species of sporozoon has been observed by me in the red corpuscles of some bovines. This will be described at a later date when time permits me to work out the various forms which it assumes.

Endoglobular Hæmosporidia.—An endoglobular Hæmosporidia, a similar form of organism to that noted as having been discovered in the erythrocytes of camels in 1903, has, during the past year, been met with in the red blood corpuscles of plains cattle brought to Muktesar for the purpose of hyperimmunization against rinderpest. It will be remembered that the red blood cells found in camels and bovines vary considerably in size, the length being as a rule 7μ and 5μ respectively.

As might be presumed, the organisms exhibited in the blood cells of the two species of animals also vary in dimensions, the development of the sporozoon in the smaller form of erythrocyte being probably inhibited in growth for want of space and to some extent on account of diminished nutrition also.

As in the camel blood, so in the bovine the long thread-like organism with one extremity terminating in a small protruberance or knob may be observed at one stage of development following the exact contour of the red blood cell, while in another it forms a figure of eight in its interior. On careful observation in some instances the situation of the knob-like extremity can be determined, but even then the two ends of the organism appear to be in continuity, while at an earlier stage of development in the camel no sign of any protruberance or want of complete continuity can be made out.

Only after long search in bovine blood may some erythrocytes be discovered which contain what appear to be mature forms of organisms, free, in the contents of the cell.

In such instances the organism is wider in the middle of its length, while one end terminates in a circular knob and the other appears to gradually decrease in diameter until it comes to a fine point.

The organism as observed in bovines has not been discovered free in the blood plasma up to the present, as was the case in camels.

When stained by the Leishman-Romanousky method, the organisms, in nearly every instance, are coloured pink or a purplish red, but in all the specimens examined no differentiation of the protoplasmic structure has been noted.

A similar form of organism to that above mentioned has also been discovered in the blood of certain equines, the subjects of spontaneous equine surra.

Hæmorrhagic Septicæmia.—This is an acute disease affecting for the most part buffaloes and cattle in this country, although it is pathogenic to some equines, deer, and to a less extent to sheep, goats, and many small animals. Country-bred horses are immune, but donkeys succumbed to inoculations of virulent blood. In some districts in this country, the disease is said to appear sporadically during the whole year, especially those localities which are marshy or intersected by rivers. The disease, however, becomes epizootic, as a rule, during the monsoon and during or after the winter rains.

Several types of this disease may be encountered in the field, *viz.*, (I) superficial or cutaneous, (II) thoracic, (III) intestinal, and these in *acute* or *chronic* form.

During the course of these researches, it has been found that hill animals are the most susceptible to hæmorrhagic septicæmia. Buffaloes and plains bovines coming next, in the order mentioned. It must, however, be distinctly recognized that the "materies morbi" differs in virulence considerably in different outbreaks, and further the susceptibility of the animals of various breeds exposed to the "contagium" likewise varies. Consequently, the periods which intervene, *viz.*, the incubation period of the malady and that between the exhibition of the first symptom recognizable and death, may also be found to vary considerably.

Experimentally it has been demonstrated that one large drop of a virulent broth culture of the organism of hæmorrhagic septicæmia inoculated subcutaneously was sufficient to bring about death respectively in buffaloes, hill and plains bovines, in the following periods:—

(1) Hill bovines in $23\frac{1}{2}$ hours,
(2) Buffaloes in 28 hours, and
(3) Plains bovines in 28 to $42\frac{1}{2}$ hours.

It will, therefore, be observed that there may be no time to treat acute cases, which frequently exhibit no symptoms of the disease, or only for a short period, *i.e.*, several hours before death.

It is laid down that one attack of this disease gives protection against a second one during the lifetime of the animal. We have found that animals which have passed through one attack of the disease and recovered, possess an active immunity after an interval of two years, and this protection may be found in future experiments to extend for a much longer period.

Preparation of Hæmorrhagic Septicæmia Serum.—The organism of this disease as obtained in cultures from the blood of animals which succumbed in the field has been found to vary in virulence to an enormous extent. Consequently, instead of utilizing several strains of the "causal agent" for the purpose of immunizing the necessary animals for the preparation of a polyvalent anti-bacterial serum, the same has been prepared at this laboratory from cultures of the organisms after passing them through a series of highly susceptible

animals until a minimal lethal dose had been arrived at. This procedure was adopted with a view to insure the serum being possessed of qualities capable, if possible, of granting in small doses a passive immunity against the most virulent strain to be encountered in the field.

Summary of some results obtained with Serum of Bovines hy per-immunized with the causal agent of Hæmorrhagic Septicæmia.—(I) The disease does not appear to infect by the gastro-intestinal tract, unless there is an abrasion; for animals drenched with large doses of virulent culture showed no symptoms during a further period of two weeks. The majority of such animals when tested with virulent culture at a later date succumbed.

(II) Hill, in contra-distinction to plains, bovines require a large dose of the anti-bacterial serum to produce protection.

(III) Plains animals respectively injected subcutaneously with a standard dose of serum still possessed a full passive protection against the inoculated disease after a period of *four weeks*, but those tested after *seven weeks* succumbed.

(IV) The same standard dose, *viz.*, 5 C. C. of serum, failed to protect hill cattle even for eight days. Such breed of cattle require a double dose (10 C. C.).

(V) Hill animals, subcutaneously inoculated by the simultaneous method (with 5 C. C. serum, 0·1 virulent culture), succumbed to the disease like ordinary unprotected animals.

(VI) Hill animals, submitted to the simultaneous method (5 C. C. serum injected intravenously, and virulent culture 35 minutes later subcutaneously), were found to be protected.

(VII) Plains and hill buffaloes injected subcutaneously with 3 C. C. of serum, and 48 hours later tested with virulent culture, were found at a later date to possess an active immunity.

(VIII) A dose of 35 C. C. of serum injected intravenously in hill cattle has been found necessary to overcome the effects of a lethal dose of virulent culture injected subcutaneously 15 hours previously. The animals thus treated presented no symptoms of the disease. Consequently this mode of treatment on account of the large quantity of serum necessary cannot be recommended, except in the case of valuable cattle being attacked, and even then, if any symptoms are exhibited, probably a much larger dose would be required than the one above mentioned.

When Bovines were hyperimmunized with the Toxins produced by the causal factor of Hæmorrhagic Septicæmia.—A plains bull, aged $4\frac{1}{2}$ years, body weight 421 lbs., susceptible to this disease, was hyperimmunized with toxin prepared from the organism of hæmorrhagic septicæmia, allowed to remain in an incubator at 37° C. from 11th October 1904 to 15th May 1905. The doses of toxins injected subcutaneously varied from 1 C. C. to 110 C. C. during a period of four months—in all a total of 626 C. C. were injected. The body weight of the animal increased during this interval from 421 to 490 lbs.

On the 18th July 1905, the animal was bled for the first time and serum prepared in order to test its immunizing power after the 8th injection, nine days after a dose of 80 C. C. had been injected. A dose of 5 C. C. serum and 48 hours later 0·1 C. C. virulent culture failed to protect the animal, but 10 C. C. under similar conditions only allowed of a slight thermal reaction and a dose of 7·5 C. C. proved sufficient to protect. The animal was bled 2,200 C. C. on the 30th August and 3,000 C. C. on the 8th September, and later, on the latter date, was inoculated with 0·1 C. C. of a culture of hæmorrhagic septicæmia to test the degree of susceptibility; a slight thermal reaction followed and concurrently a small swelling occurred at the seat of inoculation, $2 \times 1 \times \frac{1}{4}$ inches, which was quickly absorbed.

Sera produced by hyperimmunizing Bovines with certain organic substances other than the causal agent of Hæmorrhagic Septicæmia.—In a previous communication I pointed out that serum prepared by hyperimmunizing plains cattle with phytoglobulin or some nearly allied substance obtained from pumpkin seeds grown in the vicinity of Muktesar, on subcutaneous or intravenous injection into susceptible animals, was capable of conferring a resistance to the organism of hæmorrhagic septicæmia, which resistance could be changed into an active protection should the animal be inoculated with a small quantity of culture of the "causal agent." Further, that this active resistance was found to be maintained two years after the primary protection had been conferred.

During the years 1902-03, sera were also prepared by hyperimmunizing cattle with certain substances other than the causal agent of hæmorrhagic septicæmia, obtained from the testes of plains and hill cattle, and of buffaloes, and also from the seeds of plants. Additional sera were made from other organic substances, such as *milk*,

yolk of egg, fish sperm and spawn, cell-protoplasm, mucin, and *yeast.*

During the year under review certain of the above sera to which 0·5 per cent. carbolic acid was added in the first instance have been re-tested as to their protective effects on the "contagium" of hæmorrhagic septicæmia, after they have been allowed to stand in the cold room at Muktesar for periods of from 2½ to 3½ years.

The following interesting and important results were obtained:—

The minimal lethal dose of hæmorrhagic septicæmia was found to be 0·1 C. C. of bouillon culture 48 hours at 37° C.

This killed an animal of 240 lbs. body weight in 31 hours. Hill animals were respectively subcutaneously injected with the following sera prepared from *buffalo testes, yolks of eggs, casinogen, para-nucleo-proteid,* and *pumpkin seeds.*

Each animal received 1 C. C. per lb. body weight of one of the respective sera, and 48 hours later was subcutaneously inoculated with 0·1 C. C. of virulent hæmorrhagic septicæmia culture. Some of the animals showed thermal reactions and recovered, with one exception, namely, the one subjected to para-nucleo-proteid serum. This animal succumbed in 35 hours 10 minutes, a little later than the Control. Others showed no thermal reactions, a sign that the dose of serum injected was too large and therefore the "causal agent" was destroyed, without conferring any active immunity. In order to prove this supposition, the surviving animals were again, after a period of eight days, subjected to a larger dose of hæmorrhagic septicæmia virulent culture, to test their degree of protection. It was found that the animals which had respectively exhibited thermal reactions, *viz.*, those which received doses of *buffalo testes serum, yolk of egg products,* and *casinogen* survived the ordeal, and the others succumbed in various periods, demonstrating the fact that the immunity conferred was but of short duration.

In a second series of experiments with enhanced doses of hæmorrhagic septicæmia culture in the first instance, it was discovered that the serum prepared from the casinogen (milk) was the only one which stood the severe test, and in this case the animal exhibited no symptoms other than a slight thermal reaction, emphasizing the great power of this form of serum, which two years and nine months in bottles at the time of re-testing still maintained its efficacy.

38. **Charbon Symptomatique.**—Extensive researches have occupied a portion of our time during the past twelve months in attempting to procure a serum to protect against charbon symptomatique in bovines. Our greatest difficulty has been connected with the production of virulent cultures for the purpose of hyperimmunizing animals. All known methods have been tried but without success. Consequently, we have been obliged to fall back upon the use of the muscle juice of animals, which have succumbed to the disease, for the periodical injection of the serum giving animals. In due course the serum will be ready for the test experiments, as to the dose it is to be issued at.

In the field, this process of serum injection will only confer a passive protection for a short interval on the injected animal, whereas the first and the second vaccines prepared from muscle juice of animals which have succumbed to charbon symptomatique will produce an active immunity upon the injected animals after the reaction following the injection of the second vaccine. A large number of doses of various vaccines have been prepared by the following different methods and issued for testing in the field during the coming wet season. The simplest and most efficient method may then be introduced and its preparation continued :—

(i) First and second vaccines from muscle juice obtained from animals which have succumbed to charbon symptomatique.

(ii) A third form of vaccine from the defibrinated blood of bovines which have succumbed to the malady.

(iii) A fourth form of vaccine from the defibrinated blood of bovines suffering from charbon symptomatique but utilizing the heart blood collected half an hour before death.

(iv) A fifth method is to use the spleen of charbon symptomatique carcases squeezing out the juice, letting it dry, then mincing and exiccating the same over sulphuric acid.

Camel Tuberculosis.—A camel sent to the laboratory at Bareilly, as being the subject of spontaneous trypanosomiasis, remained under observation from the 23rd November 1905 until 11th January 1906. During this period the daily examination of the peripheral blood revealed no sign of flagellates. The animal was in poor condition, but continued to feed well until 11th January, upon which date death took place somewhat suddenly whilst in the sitting position.

The autopsy conducted shortly after death revealed an extraordinary condition of the posterior halves of both lungs. The anterior halves were normal in character, but the visceral pluræ of the posterior portions exhibited an appearance resembling that of a thin turtle shell, convex, hard, smooth, and the affected portions were exceedingly heavy. A strong knife made no impression upon the tissues, it was necessary in order to obtain a section of the posterior portion of the organs to have recourse to a saw. On section, the exposed surfaces exhibited an appearance resembling the cancellous structure of bone, the interstices being here and there occupied with material resembling the marrow from the shaft of a femur. One enormously enlarged post-tracheal gland was removed, which, on section, revealed extensive tubercular changes.

Two guineapigs were inoculated with an emulsion of the lung of the camel, and the two series of three were carried on by inoculation of further small animals, with the tissues of those which succumbed. Three animals were utilized in all in each series; the results obtained were as follows :—

In the first series, the guineapigs succumbed on the 96th, 76th, and 96th day after inoculation, while in the second series, death took place on the 114th, 57th, and 51st day, showing that by passage through the guineapig the virulence of the organism is rapidly increased for that aninal. A hill bull subcutaneously inoculated also with 1 C. C. of lung emulsion presented but very slight swelling at the seat of the inoculation, which disappeared within a few days.

The rectal temperature of this animal oscillated but little until a period of six weeks had elapsed from the date of injection. It then rose from 36·8 to 39·3° C. and a few weeks later became intermittent in character; this intermittence persisted for a period of three weeks, but during a later spell of eighteen weeks the temperature remained almost stationary between 37 and 38° C.

On the 20th September, the animal was tested with tuberculine. Temperature 37·4° C., an acceleration on the evening of the 21st occurred 38·6° C., and since that date the temperature has registered a degree centigrade higher than was the case previous to the exhibition of tuberculine. It would, therefore, appear that this bull must have some focus of infection, but in what part of the body it is impossible to say.

The bacillus when stained and treated with nitric acid, according to Koch's method, although an acid fast organism differs materially in form from the *typus bovis*, later, however, when passed through guineapigs, it again retroverted to that form.

A list of publications contributed during 1905-06 from the Imperial Bacteriological Laboratory.

LINGARD, A. Annual Report of the Imperial Bacteriological Laboratory for 1905-06.

A note on Hæmorrhagic Septicæmia.

A new species of Trypanosoma found in the blood of Rats, together with a new metrical method of standardizing the measurements of trypanosomata. *Journ. Vet. Science*, i, No. 1, p. 5.

Through what agency is the Trypanosoma Evansi carried over from one Surra season to another? *Journ Vet. Science*, i, No. 1, p. 92.

Ocular Filariæ of Equines and Bovines. *Journ. Vet. Science*, i, No. 2, p. 175.

Flagellates found in the Gastro-Intestinal tracts of the Horse-Leech, Hæmopis Sanguisuga. *Journ Vet. Science*, i, No. 3, p. 301.

The significance of the pyriform, circular and irregular-shaped bodies present in the circulation, organs or tissues in various forms of disease in man and animals, with suggestions regarding their identification and classification. *Ind. Med. Gaz.*, vol. xl, Nos. 9 and 10.

Some flagellate forms found in the intestinal tracts of Diptera and other genera. *Messrs Adlard & Son, London.*

MONTGOMERY, R. E. Observations on Bilharziosis among animals in India. *Journ. of Vet. Science*, i, No. 1, p. 15, and No. 2, p. 138.

An Anthrax-like bacillus found in a horse suspected of Anthrax. *Jour. Vet. Science*, i, No. 3, p. 284.

BALDREY, F. S. H., & MARTIN, G. D. — A disease of the Horse simulating Farcy from which an organism possessing many features in common with bacillus mallei was isolated. *Journ. of Vet. Science*, i, No. 3, p. 316.

A list of papers published during 1905-06 bearing on such diseases.

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BALDREY, F. S. H. . . White Scour. *Journ. of Vet. Science*, i, No. 2, p. 211.

BLANCHARD, R. . . Spirilla, Spirochætes and other spirally formed micro-organisms. *Journ. of Vet. Science*, i, No. 3, p. 320.

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HOLMES, J. D. E. . . The Rôle played by biting flies in the spread of Trypanosomiasis. *Journ. of Vet. Science*, i, No. 2, p. 119.

LAVERAN, A. . . . The classification of Hæmocytozoa. *Journ. of Vet. Science*, i, No. 2, p. 242.

MACKIE, F. P. . . . A case of Intra-ocular infection by tetanus in a foal. *Journ. of Vet. Science*, i, No. 2, p. 208.

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PEASE, H. T. . . . Tibarsa Surra-Trypanosomiasis in Camels. *Journ. of Vet. Science*, i, No. 1, p. 71, and No. 2, p. 127.

TURNER, G. . . . Rinderpest in South Africa. *Journ. of Vet. Science*, i, No. 3, p. 269.

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PROGRAMMES OF WORK FOR 1906-07.

PROGRAMMES OF WORK OF THE VARIOUS SCIENTIFIC DEPARTMENTS FOR THE YEAR 1906-07, AS APPROVED BY THE BOARD ON THE 5th MAY 1906.

1. The Director of the Imperial Institute and The Reporter on Economic Products.

1. Samples of Indian Turpentine have been sent to the Imperial Institute for report and exhibition to merchants, and will be reported on.

2. Dammars are being studied, botanically by the Reporter on Economic Products, and chemically by the Curator of the Indian Museum, Industrial Section.

3. Myrrh, frankincense, byssabol, habaghadi and allied substances are being studied by the Reporter on the basis of his Circular Note on Enquiry No. 157.

4. All samples of rubber of any importance are systematically sent to Professor Dunstan who reports on them chemically and submits them to brokers. It is intended, with the consent of the Inspector General of Forests, to give special attention this year to *Ficus elastica* in order to ascertain if the produce of the Charduar plantation can be improved in some way. Professor Dunstan suggests that to stimulate interest in the development of rubber planting in India, samples of rubber obtainable from the various Indian plantations, on which Para, Ceara, and Castilloa rubbers are being tried, should be sent to the Imperial Institute for examination and valuation. Anything that can be done in this direction will be done.

5. Reports on tanning extracts from the bark of *Shorea robusta* and *Terminalia tomentosa* will be given by the Imperial Institute during the coming year. Study of the pods of *Cæsalpinia digyna* and Mangrove extracts will be made.

6. Fibres received by the Reporter on Economic Products are systematically sent to Professor Dunstan for analysis and report, but can now be tested for strength in the Indian Museum before being sent. The Reporter on Economic Products this year is interested in the improved preparation of *Agave* fibre, and in the finding of brush

fibres that could be produced in India. There is to be maintained at the Imperial Institute a special exhibition of Indian and Colonial cottons, and if India has any good produce to send it will be sent.

7. The pharmacological investigations in hand are continuations of those which were in hand last year. The study of Aconites is to be prosecuted by Professors Dunstan and Cash, and the species under special investigation are *Aconitum heterophyllum*, *A. spicatum*, *A. laciniatum*, *A. palmatum*, and the Gilgit Aconite believed to be *Aconitum soongaricum*. Further material for this study will be collected by the Reporter on Economic Products.

8. The study is being prosecuted by physiçians in India who work on material provided by the Indigenous Drugs Committee of the following drugs :—*Adhatoda vasica*, *Alstonia scholaris*, *Cæsalpinia Bonducella*, *Calotropis procera*, *Embelia Ribes*, *Ipomæa hederacea*, *Picrorhiza Kurrooa*, *Podophyllum Emodi*.

9. Mr. Hooper is working on Burmese Cutch with a view to suggesting a standard for the drug—a necessary preliminary to its use.

10. The Reporter on Economic Products has in hand the collection of information upon the gentianaceous bitters of India.

11. Chemical analyses are in progress at the Imperial Institute of *Hyoscyamus niger*, *H. reticulatus*, *Datura Stramonium* and *Datura fastuosa*, sufficient material having been supplied from India. The idea underlying the investigation is the possibility of sending supplies of these from India to the European drug market.

12. Material sent to the Imperial Institute for investigations on Strychnos beans, etc., will be examined there.

13. A report on the races of Juar (*Andropogon Sorghum*) in India will be drawn up during the year by the Reporter on Economic Products.

14. Rice grain will be subject to chemical examination by the Curator, Indian Museum, Industrial Section, with special reference to its uses as a material for making sizes.

15. A report on the Yams (*Dioscorea* spp.) of India will be drawn up during the year by the late Director of the Botanical Survey and the Reporter on Economic Products.

16. The chemical examination of the seeds of *Lathyrus sativus* will be continued at the Imperial Institute as soon as the Government of India calls for further studies, but it is first desirable to find a

particularly poisonous race with undoubted evil effects on some animal that can be subjected to experiment.

17. Further steps will be taken by the Reporter on Economic Products to put very young plants of *Andropogon Sorghum* into the hands of Professor Dunstan for the search in them for a glucoside which yields prussic acid, and leads to the poisoning of cattle.

18. The study of cyanogenetic glucosides in Cassava (*Manihot utilissima*) and other plants is being prosecuted at the Imperial Institute.

19. Trades in animal products are being worked up, and material is forwarded to Sir George Watt for inclusion in his handbook of Indian Economic Products. Such trades are those in dried meat, dried fish, bones, lard, pigs' bristles, etc.

20. Bauxite will be the subject of a report from the Imperial Institute, the material having been supplied by the Director of the Geological Survey.

21. Manganese ores are similarly under investigation.

22. Pottery clays by arrangement with the Director of the Geological Survey have been collected by the Reporter on Economic Products and will be examined chemically by Professor Dunstan.

2. Meteorological Department.

Astronomy.—The routine work at Kodaikanal will include:—

(*a*) photographing of the sun in monochromatic light by means of the new spectroheliograph fed by a twelve-inch lens;

(*b*) spectroscopic observations of sunspots and prominences by means of an Evershed spectroscope;

(*c*) photographing the sun in ordinary light by means of a photoheliograph.

If, as is hoped, a European assistant joins the staff, it is intended also to make use of a spectrograph, consisting of a grating fed by a six-inch lens of 40 feet focus, for the more detailed examination of the spectra of sunspots.

Arrangements have been made for full co-operation with the International Solar Union, a representative body of astronomers with Professor G. Hale as chairman.

Magnetism.—The magnetic observations which have been made since 1846 at Colaba will terminate on the 31st March 1906 and will

be transferred to Alibag, with which station a comparison has been in progress for slightly over two years.

Considerable progress has been made with special tabulations of the records of the past 60 years and the Director will continue his discussion of them during the year.

Meteorology.—*Study of the Monsoon Region.*—The work of the past year has brought to light relationships between certain extra-Indian conditions and the subsequent rainfall of India, including that of the south-west monsoon proper, of the retreating south-west monsoon and of the cold weather: the most prominent of these conditions appear to be the pressure at Mauritius and the rainfall at Zanzibar and Seychelles. A series of monthly charts of the monsoon region for the past thirty years, so far as data of pressure and temperature are available, has been prepared and an endeavour will be made to obtain further insight by their means.

Arrangements have been made for obtaining the logs of ships in the Indian Ocean from London, Mauritius, Washington, and Berlin, as well as from Calcutta and Bombay. The plotting of their data will be commenced and a series of monthly marine maps will be constructed. These will be of value as supplementing the data of the fixed observatories.

Pilot Charts.—The materials for an atlas showing the normal monthly conditions, as regards pressures, winds and currents, for the Indian Ocean north of latitude 12° S have been prepared: material progress with its publication will be made by Messrs. Bartholomew during the coming year.

Study of the Upper Atmosphere.—*Kites.*—It is proposed to undertake investigations with meteorographs raised by kites at the time of the approach of the monsoon, and Belgaum will probably be visited for the earliest part of the work. An oil engine and large winding machine should be in readiness by the end of April, and with these it is hoped to reach greater heights than were attained last year in trials of the apparatus which were made with a handwinding machine. Experiments will be made on the various electrical conditions of the atmosphere up to the heights reached by the kites.

Balloons.—Experiments with balloons of paper and other materials, whose motions have been observed by theodolites at two stations, have been carried on during the past year and have indicated the lines on

which future work should be done. Non-expanding open balloons of guttapercha tissue and closed expanding balloons of thin india-rubber sheet will be used for determining the directions and velocities of upper currents at times when no indications on these points are afforded by the presence of cirrus cloud : this work will, for the present, be mainly confined to the neighbourhood of Simla.

Daily Weather Work.—*Storm and Flood Warning.*—Files are being prepared of charts of reduced size showing the pressure at 8 hours, the pressure changes of the previous 24 hours and the resulting rainfall during the succeeding 24 hours. This work will be continued and the charts used for checking of the forecasts issued as well as for future reference.

It is also proposed to make further progress with the preparation of files of charts of typical depressions and cyclonic storms for rapid examination when similar disturbances are affecting the weather.

An effort is to be made during this year's tours by gazetted officers to obtain more definite and detailed information from the recipients of flood warning telegrams as to local requirements and conditions in respect of such warnings, with a view to improving the present methods of the department.

Chur Peak.—Experiments are being made with a special form of recording barometer to register without attention for four months at a time, and if the apparatus proves successful it is probable that it will be put into work on the summit of the Chur Peak in the course of the year. The purpose in view is to obtain a close record of pressure at the higher station (inaccessible and unattended during the winter months) and by the help of the observer at an inhabited station lower down the mountain to secure accurate information regarding vertical pressure gradients.

Solar Radiation.—Electrical solar radiation thermometers are to be systematically used, and it appears desirable to begin observations at Simla and at Roorkee with two of Angstrom's Compensation Actinometers. These instruments have been adopted by the International Solar Union as standards for absolute measurements of solar radiation. A beginning will be made of a series of comparative readings of the ordinary black bulb radiation thermometers which have long been in use in India with the Angstrom standards in order to settle the still doubtful point whether material alterations occur in the emissivity of the blackened surface of the bulbs.

Atmospheric Electricity.—Apparatus is now on order suitable for the measurement of electric potential in the air, and on arrival it will be put up for work in Simla; continuous automatic records will then be made. The ionisation of the air also will be measured at intervals by means of an Ebert's aspirated ionisation apparatus, and comparative determinations will be made of the amounts of radio-activity in the atmosphere, the apparatus employed being a metal collector maintained at a high negative potential and examined periodically by electroscopic means.

Daily observations are being taken at Alipore of potential gradients and of ionisation values in the air, and of the velocity of the ions themselves. The latter gives information as to the extent to which the ions have become loaded up as nuclei for the formation of dew, mist and cloud in which respect their influence is important but has been little investigated.

Seismography.—A Japanese seismograph which was lent to the Department by Professor Omori, has been in use at Simla for several months, and records of many earthquakes have been obtained. A completely modern equipment is now on order from Japan, and will be put up in a permanent manner in Simla on its arrival. The records will then embrace the northerly component of earth movements of distant origin, and shocks of near origin will be recorded by one vertical and two horizontal pendulums. The existing seismographs at Bombay, Calcutta, and Kodaikanal will remain in use.

3. Survey of India (Research Work).

Gravimetric Survey.—Pendulum observations will be taken at stations of the Great Arc of India between Dehra Dun and Central India. One Pendulum station at least is required on the Siwalik hills, and one or more on the Vindhyan chain.

Magnetic Survey.—Colaba Observatory under the Meteorological Reporter and the four observatories under the Surveyor-General will continue to work; observations will be taken at twenty-four Repeat stations and the preliminary field work will be continued for India and Burma with the intention of completing it in the following year.

Solar Photography.—Photographs of the Sun will be taken daily at 10 A.M. and 4 P.M. at Dehra Dun, as has been done since 1879 in conjunction with Greenwich.

Himalayan Geography.—The number of travellers in the Himalayas and Tibet is increasing and a wider interest is being evinced by the public in the geography of these regions. It is, therefore, proposed to compile a paper, summarising the geographical position at the present time.

4. Geological Survey.

(*a*) Continuation of the investigation of the copper-sulphide deposits in the Singbhum District.

(*b*) Examination of the copper-sulphide deposits in Kumaon.

(*c*) Examination of the tin ore and wolfram deposits in South Burma.

(*d*) Preliminary examination of certain glaciers in Kumaon with a view to drawing up instructions for the measurement of their movements.

(*e*) Extension of geological work over unsurveyed areas in Central India and Rajputana.

(*f*) The survey of unmapped areas in the North-West Frontier Province.

(*g*) The survey of unmapped areas in Upper Burma, beginning in the Tertiary oil-bearing tracts.

(*h*) An examination of the salt deposits in the Salt Range, partly with regard to the origin of the salt-marl, and partly for the purpose of discovering the quantity and distribution of potash and magnesian salts.

(*i*) Borings for artesian water in Gujarat, north-east of Wadhwan.

5. Botanical Survey.

I.—Country under the Superintendent of the Royal Botanic Garden, Calcutta.

(*a*) **Bengal.**—An endeavour will be made to make a representative collection of the plants found in one or more of the districts of Bengal to be utilised, it is hoped, ultimately in the preparation of district lists.

(*b*) **Assam and Burma.**—The same policy will be pursued as far as possible within Assam and Burma.

II.—Survey of Bombay.

Mr. Gammie, the Officer in charge of the Survey of Western India, proposes during the year 1906-07 to continue special investigations on the Ghats, some of the Deccan districts, Guzarat and possibly Sind.

III.—Survey of Southern India.

The Government Botanist, Madras, will endeavour to undertake during 1906-07 a tour in Travancore for Botanical Survey purposes, if it can be done with due regard to the proper carrying out of the economic duties of the Government Botanist.

IV.—Survey of Northern India.

The Economic Botanist to the Government of the United Provinces reports that he has no programme of operations of the Botanical Survey for 1906-07.

V.—Economic Investigations.

The economic investigations at present in hand will be continued. These are as follows:—

(*a*) Indian cottons.
(*b*) Fibre-yielding plants.

6. Agricultural Departments.

Section I.—Pusa Agricultural Research Institute.

(a) **Agricultural Chemistry.** — The Imperial Agricultural Chemist will be employed mainly on the investigation of the following problems:—

(1) The availability of plant food (more especially phosphates) in soils, with reference to Dr. Dyer's method of determination, will be studied in the laboratory and Pot-Culture House.

(2) The diffusion of soluble salts, such as nitrates, through soils, will be the subject of a series of tests.

(3) The composition of rain-water, dew and drainage water will be further investigated. The percolation through the soil will be determined in the special drain-gauges now under construction. In addition, a series of tests will be made to determine throughout the year the amount of water at varying depths in the soil.

(4) Amongst minor investigations may be mentioned (*a*) the testing of calcium cyanamide as a manure; (*b*) the analysis of sugarcane juice; (*c*) the conditions under which the quantity of glucoside varies in *Andropogon Sorghum* and *Manihot utilissima*.

(5) The ordinary analytical work of the laboratory will be continued, special attention being given to the composition of food grains and oil seeds.

(b) **Mycology.**—The programme of the Imperial Mycologist includes the following subjects:—

(1) The investigation of soil fungi in their relation to plant life, with special reference to the symbiotic relation between certain fungi and the roots of a number of higher plants, and also the part played by fungi in the decomposition of organic matter in the soil.

(2) The investigation of the wilt-producing fungi of pigeon pea, pepper and other crops.

(3) The investigation of a serious disease of mangoes in Bengal, caused by an algal parasite.

(4) The study of sugarcane diseases.

(5) The investigation of cereal and flax rusts, more particularly of wheat.

(6) The study of a number of other fungus diseases of crops.

(7) The continuance of the systematic survey of the Indian fungi.

(c) **Entomology.**—

(1) The principal work of the Imperial Entomologist will be the trial of remedies for injurious crop pests on experimental farms, based upon the results of the investigations of previous years, which are being published in a book on Indian Insect Pests.

(2) The treatment of insect pests infesting the crops grown at Pusa will be continued.

(3) The work at the Insectary will include (*a*) an investigation of the relation of climatic changes to the life histories of insects; (*b*) the study of methods of increasing the beneficial action of parasitic insects; (*c*) the testing of the action on insects of substances innocuous to cattle; and (*d*) the working out of the life-histories of new crop pests.

(4) The insect survey of India will be continued, assistance in the identification of insects being obtained from workers in other countries.

(5) Assistance will be given in measures for the suppression of a second outbreak of boll-worm in cotton in the Punjab, a scheme of operations having been framed which includes the growth of trap crops, the introduction of beneficial parasites from other parts of India, and other remedies.

(d) **Economic Botany.**—The Economic Botanist will devote his attention to the following subjects :—

(1) The completion of the laying out of the Botanical garden, including a special section devoted to fibre plants.

(2) The improvement of Indian wheat, more particularly the rearing of new varieties by cross-breeding.

(3) The study of varieties of Indian tobacco and cotton, more particularly for the elucidation of certain fundamental problems connected with the methods of fertilization of the flowers.

(4) Permanent experiments on the treatment of Indian fruits.

(e) **The Experimental Farm.**—As the land has now been brought into cultivation, a regular series of tests under uniform methods of treatment will be commenced in order to prepare the way for comparative experiments. Special investigations will also be made of (*a*) the yield and feeding value of some of the more common fodder crops, both under irrigation and natural moisture; (*b*) methods of cultivation of sugarcane and the testing of varieties; (*c*) the improvement of the pastures of the farm; and (*d*) the improvement of the herd of indigenous cattle for the supply of breeding bulls, and the testing of the Montgomery dairy herd for their acclimatization as milch cattle.

(f) **General.**—In each special branch arrangements have been made for the training of probationers for provincial departments. It is anticipated that the College for post-graduate study will be ready to open by the end of 1907.

SECTION II.—SPECIAL INVESTIGATIONS.

The following special investigations, which will be conducted in co-operation with provincial departments, will be continued or started :—

(1) The improvement of India cotton. One stage of the survey of indigenous varieties has been completed, for the present, by the publication of Professor Gammie's Note on "The Indian Cottons." The remaining work will be continued in accordance with last year's programme.

(2) The improvement of Indian wheat will be taken up in accordance with a programme laid down by the Board of Agriculture, which includes an agricultural survey of the wheats in each province ; tests of their milling and baking qualities ; endeavours to secure uniformity of sample ; experiments in rotations, manures and the like ; improvement in methods of storage ; the study of fungus diseases and insect pests ; and, above all, the breeding of new varieties to suit special local conditions, such as improved varieties for export, rust-resistance, drought-resistance and the like.

(3) The improvement of Indian tobacco will similarly be taken up in important tobacco-growing tracts under a scheme which includes a study of existing conditions of production ; an investigation of tobacco soils and waters ; a survey of local varieties ; the investigation of fungus diseases and insect pests ; the production of tobacco suited for European consumption by the trial of exotics, improvement in methods of cultivation and harvesting, and above all by improvements in methods of curing.

(4) Other crops that are the subjects of special investigation are (*a*) Tea, under the scientific department of the Indian Tea Association ; (*b*) Indigo, under the scientific department of the Behar Planters' Association ; and (*c*) Jute, under the Jute Specialist to the Government of

Eastern Bengal and Assam. Each of the programmes of work is similar to that given in the last Annual Report of the Imperial Department of Agriculture.

(5) The trial of commercial fertilizers for Indian crops will be started on regular lines, more particularly the testing of mineral fertilizers for cotton, sulphate of ammonia for sugarcane, and the introduction into more common use of saltpetre as manure.

SECTION III.—PROVINCIAL DEPARTMENTS OF AGRICULTURE.

The programmes for next year generally follow those described in last year's programme placed before the Board of Scientific Advice, but the following important additions may be noticed : —

(1) In the United Provinces a survey of wells and well waters is in progress. The special crops under study are sorghum, poppy, wheat and cotton.

(2) In Madras, special experiment stations have been started for (*a*) the improvement of groundnut ; (*b*) the study of pepper-vine diseases ; and (*c*) irrigation experiments in black soil.

(3) In the Punjab, additional Government farms are being started, more particularly for seed production.

(4) In Eastern Bengal and Assam the programme includes a tobacco experiment station at Rangpur and a sugar station at Jorhat.

(5) Schemes for the expansion of all provincial departments have been framed in accordance with the general outline given in paragraph 47 of the Annual Report of the Imperial Department of Agriculture.

7. Forest Department.

1. The examination of tannin extracts, more particularly with extract obtained from barks of common Indian species of trees by the decolorising process suggested by the Director, Imperial Institute, London, will be continued.

2. The results of the investigations carried out in 1904-05 by an expert in connection with the utilisation of inferior species of trees and of bamboos, in the form of wood-pulp, will be considered with the object of starting a profitable industry in the manufacture of marketable wood-pulp.

3. The question of the supply of soft wood sleepers for Indian railways where hard woods are not available will not be lost sight of. Railways desiring to experiment with such sleepers will be furnished with samples at the cost of delivery only, and it is hoped that some steps will be taken to commence enquiry into the life of impregnated soft-wooded sleepers under traffic.

4. Investigations will continue to be made by the Imperial Forest Entomologist into the injuries to forest growth caused by various insect pests in different Provinces, and the best methods to adopt in order to combat the ravages of these pests will be considered.

5. The collection of specimens of timbers and other forest products will be continued for supply to the Director, Botanical Survey, and the Reporter on Economic Products. Seeds of the more important indigenous species will continue to be collected and sent for experimental cultivation to various British Colonies.

6. The collection and analysis of the latices of rubber-producing species will be continued, and experiments will be carried out in the Government Rubber plantations of Assam with the object of ascertaining the best methods of tapping the *Ficus elastica* in order to produce a full flow of latex with a minimum bark injury. Investigations will also be made in the endeavour to determine the causes responsible for the undue proportion of resin in the rubber from this species.

7. **Publications.**—Forest Bulletins setting forth the results of investigation into various subjects affecting the progress of Indian forestry will be published from time to time.

8. Zoological Department.

NATURAL HISTORY SECTION, INDIAN MUSEUM.

It is expected that the routine work of the Museum will occupy almost all the official time of the two officers who constitute the staff, but in private time the Superintendent hopes to continue the systematic investigation of the marine fauna of India and the Deputy Superintendent that of the fresh water invertebrate fauna of Bengal.

9. Civil Veterinary Department.

1. **Rinderpest.**—Further experiments with the view of raising the potency of anti-rinderpest serum.

2. (*a*) **Piroplasmosis**; (*b*) **Trypanosomiasis**; (*c*) **Malignant Oedema.**—These three diseases have been observed at the Laboratory appearing as secondary diseases to Rinderpest in cattle. These diseases will be further investigated as to their prevalence, the course they run, and their effect as a disease secondary to Rinderpest.

3. **Surra.**—Investigations will be carried out both in the Laboratory and the Field :—

In the Laboratory	(*a*) To attenuate the Trypanosoma by means of cultures.
	(*b*) To attenuate the Trypanosoma by passing through bodies of animals other than equines.
In the Field	(*a*) To define the tracts or belts in which Surra is endemic.
	(*b*) To investigate what may be called the Natural History of Surra Trypanosoma.

4. **Anthrax.**—Investigations will be made with a view to discover a method of conferring a more lasting immunity.

5. **Charbon Symtomatique.**—The working out of the most suitable protective agent.

6. **Dourine.**—Experiments with regard to the treatment of Dourine.

7. Tetanus anti-toxin and Anti-streptococci serum, will be prepared.

APPENDIX.

APPENDIX.

ECONOMIC INVESTIGATIONS CONDUCTED AT THE IMPERIAL INSTITUTE FOR INDIA.

BY

W. R. DUNSTAN, M.A., LL.D., F.R.S.,

Director of the Imperial Institute.

Numerous investigations relating to the composition and utilisation of Indian products have been conducted in the Scientific and Technical Department during the past year at the request of various departments, etc., in India conveyed through the Reporter on Economic Products.

The more important of these are described below.

Drugs.—*Aconites.*—The investigation of the alkaloids of various Indian aconites has been continued during the year. Three papers have been communicated to the Chemical Society of London and published in the "Transactions." Copies of these papers have been transmitted to the Officiating Reporter on Economic Products to the Government of India. The titles of these papers are:—(1) "Indaconitine, the alkaloid of *Aconitum chasmanthum*;" (2) "Bikhaconitine, the alkaloid of *Aconitum spicatum*," by Professor Dunstan and Mr. A. E. Andrews; and (3) "The aconitine group of alkaloids," by Professor Dunstan and Dr. T. A. Henry.

In the first two papers the chemistry and properties of the two new alkaloids, indaconitine and bikhaconitine, are described, and in the third the general relationship of the group of aconitine alkaloids is discussed.

The investigation of the roots of the following aconite species has also been continued during the year:—*Aconitum laciniatum*, the hybrid *Aconitum laciniatum* × *Aconitum spicatum*, "*Aconitum? Soongaricum*," *Aconitum heterophylloides*, and "*Aconitum Napellus* from Gilgit," but work on several of these is delayed by want of material.

Solanaceous Drugs.—A large number of samples of various Indian species of *Hyoscyamus* and *Datura* have been received for examination. Considerable progress has been made with this work, and it will probably be possible to issue a preliminary report shortly.

Opium.—A further report on samples of the opium alkaloids prepared at Ghazipur was made during the year. Progress has also been made with the investigation, having for its object the improvement of the processes now in use at Ghazipur for the manufacture of alkaloids from waste opium and their purification.

Hops.—A sample of hops from Kashmir has been examined and a report forwarded regarding its commercial value.

Rubber.—During the period under review a number of specimens of rubber, derived from both wild and cultivated plants, have been received from India for examination.

A sample of the latex of *Parameria glandulifera* was forwarded by the Forest Department in Burma, and the results of its examination prove that the rubber yielded by this plant is of good quality, and that if well prepared it would be saleable at very satisfactory prices.

A quantity of the prepared rubber of *Parameria glandulifera* was also submitted from the Andamans, where the plant is said to be very common. The rubber was very satisfactory in chemical composition, but its commercial value was depreciated by the fact that it had been over-heated, either during preparation or in transit, and arrived here in a sticky condition. If this defect were remedied there is no doubt that the rubber would find a ready market.

A specimen of the rubber of *Cryptostegia grandiflora* was received from Bombay where the plant is abundant. Samples of this rubber from Teynampett and Jalaun have been previously reported on. The rubber from Bombay was of very promising quality, though it contained a considerable amount of vegetable and mineral impurities. The sample was valued at 3*s.* 6*d.* per lb. in London (compared with fine hard Para at 5*s.* 4*d.* per lb.), and it is certain that a higher price would be realised by a well-prepared consignment. It has been suggested that two or three hundredweight of this rubber should be carefully prepared and sent to London for sale.

These two climbing plants, *Parameria glandulifera* and *Cryptostegia grandiflora*, which are indigenous in India, are deserving of further attention as sources of rubber.

Two samples of Para rubber (*Hevea brasiliensis*) have been received recently from Mergui and also two specimens of *Ficus elastica* rubber from the Kulsi Plantation, Kamrup. These are at present under investigation.

The question of the quality of rubber producible in India is one which should now receive detailed attention and it is hoped that further samples will be sent.

Fibres.—*Nannorhops Ritchieana.*—A sample of fibre from the leaves of a dwarf palm, *Nannorhops Ritchieana*, was examined by the usual methods. The results showed that the fibre was not of very high quality and was particularly poor in cellulose. Although the fibre would doubtless be of considerable use locally, its commercial exploitation would probably be inadvisable in view of the many superior fibres produced in India.

Aloe Fibre from Madras.—Six samples of fibre, forwarded from Madras by the Agri.-Horticultural Society, were submitted to chemical and mechanical tests and were referred to commercial experts for valuation. The plants having been grown at different heights varying from sea-level to 4,000 feet, it was of interest to ascertain whether the elevation exerted any influence on the quality and strength of the products. The samples consisted of two specimens of *Agave Vera-Cruz*, two of *Agave sisalana*, one of *Agave Wightii*, and one of *Furcræa gigantea*. The results indicated that the fibres were of fair marketable quality, but could be greatly improved by more careful preparation. No definite evidence could be obtained as to the influence of the elevation at which the plants were grown on the properties of the fibres, since the variation in the degree to which the samples had been cleaned was so considerable as to obscure the inherent quality of the actual fibre substance.

Cotton from Singbhum.—A sample of cotton (*Gossypium arboreum*) from the Singbhum district forwarded by the Department of Agriculture, Bengal, was examined and found to be of a harsh, woolly character, of very fair quality and readily saleable in the London market. Its chief defect was the presence of a quantity of very short fibre which would render it somewhat wasteful in the processes of manufacture.

Kapok.—A consignment of "kapok" (*Eriodendron anfractuosum*) from the South Arcot district, Madras, was forwarded by the Officiating Reporter on Economic Products to the Government of India. The material was found to be superior to the average quality of the Indian product and equal to good Java kapok, but contained a considerable quantity of seeds. It was recommended that the seeds should

be removed before shipment as their presence reduces the value of the material. Specimens of the product were placed on exhibition in the Indian Section of the Imperial Institute and at the Trade Enquiry Office in the city.

Musa Sheaths.—A sample of the sheaths obtained from *Musa textilis* has been received from Bombay and is at present being investigated with special reference to its value as a paper-making material.

Tanning Materials and Dyestuffs.—The investigation of the barks of *Shorea robusta* and *Terminalia tomentosa* has been continued. Reference was made in the previous report to the fact that a process had been devised at the Imperial Institute for preparing satisfactory tanning extracts from these barks, and had been communicated to the Forest Department through the Officiating Reporter on Economic Products.

Samples of extracts prepared by this process at the Tanning Extract Factory at Rangoon were received during the year and examined. The results show that the extracts made from these materials by the new process are lighter in colour and of better quality than those prepared by the usual process. The extracts are, however, still unsatisfactory in certain ways, and a report drawing attention to these points is in preparation. Two samples of mangrove extract made by the same process at the Rangoon Factory were also received. These are of good quality and their exact commercial value in this country is being ascertained.

A sample of *Xylia* extract was also examined. This proved to be rich in tannin, but the experts to whom it was submitted for valuation stated that the leather produced by it was so dark in colour that the extract could not be used as a tanning material in this country.

Samples of kino, prepared (*a*) by the usual process and (*b*) by boiling, have also been examined during the year and reported on.

Four Indian dyestuffs, *viz.*, *Hibiscus Sabdariffa*, *Onosma echioides*, *Thespesia Lampas* and *Baccaurea sapida*, are still under investigation by Mr. A. G. Perkin of the Leeds University.

Prussic Acid in Plants.—Further progress has been made during the year with the investigation of "cyanogenesis" in plants, and the glucoside phaseolunatin, first isolated at the Imperial Institute from the beans of *Phaseolus lunatus*, has been found to occur also in flax

and cassava and to be the source of the prussic acid which, as has long been known, is generated by these two plants under certain conditions. The following papers on this subject have been communicated to, and published in the proceedings of, the Royal Society during the year:—(1) On the occurrence of Phaseolunatin in Flax, by Professor Dunstan and Drs. T. A. Henry and S. J. M. Auld; (2) On the occurrence of Phaseolunatin in Cassava, by Professor Dunstan and Drs. T. A. Henry and S. J. M. Auld. Copies of these papers have been sent to the Officiating Reporter on Economic Products.

In connection with this subject reference may be made to the recent large importation of the beans of *Phaseolus lunatus* into the United Kingdom and other European countries from Java. These beans have been sold under the name of "Java beans" for edible purposes. As a result numerous cases of the poisoning of cattle and even of human beings by them have occurred, and the subject has aroused a considerable amount of attention. In connection with this matter numerous samples of Java beans and of Burma and Rangoon beans (also produced by *Phaseolus lunatus*) have been submitted to the Imperial Institute for report by merchants and others importing East Indian peas and beans.

Articles summarising the results obtained have been published in the "Bulletin of the Imperial Institute," 1904, IV, 373, and a further article will be printed in the next number of the Bulletin to be issued in December of the present year.

Foodstuffs.—*Tea.*—At the suggestion of the India Office a comparative investigation of typical samples of Indian and Chinese teas has been carried out. The results show that these Indian teas are markedly richer in caffeine, the alkaloid to which the stimulating effect of tea is due, than Chinese teas, and also yield to hot water a larger quantity of extractive matter, whilst they also contain more tannin than the Chinese teas examined.

Coffee.—Samples of coffee grown in Mysore have been submitted by the Agri-Horticultural Society for examination with a view to ascertaining whether any change in the composition of the coffee berries had been brought about by the application of manures to the land on which the shrubs were grown. A report on these samples is in preparation.

Resins and Volatile Oils.—Further samples of turpentine oil and resin prepared from *Pinus longifolia* were received during the year

and are still under investigation in connection with the general enquiry into the properties of Indian turpentine oils referred to in last year's report.

A sample of the resin of *Hopea odorata* was also examined and reported on.

Oils.—Samples of the oils of *Amoora Rohituka* and *Calophyllum tomentosum* have been received recently and are under investigation.

Minerals.—*Manganese Ores.*—A series of eighty-three samples of manganese ores was received from the Geological Survey of India through the Officiating Reporter on Economic Products in March 1905. The analyses of these were completed during the present year, and a report giving the results and commercial valuations based on these has been forwarded.

Laterites.—A series of six samples of Indian laterites has been examined and valued. A report on the results of this investigation is in preparation.

Pottery Clays.—A large collection of Indian pottery clays was received for investigation from the Officiating Reporter on Economic Products in 1904 and other samples have been received subsequently from time to time.

This investigation has been somewhat delayed owing to the difficulty of arranging for the technical trial of such a large collection.

An installation of furnaces for pottery trials has, however, been erected recently in the Imperial Institute laboratories, and rapid progress with the investigation of the "working" and "firing qualities" of these Indian clays is now being made.

Among miscellaneous minerals submitted by the Geological Survey and examined during the year may be mentioned (1) mica from Ajmer, (2) a concentrate supposed to contain pitchblende, and (3) asbestos from Southern India.

Reports.—The following is a list of the reports forwarded to India during the year 1905-06:—

Report on six samples of Fibre from Madras.

Report on the latex of *Parameria glandulifera* from Burma.

Report on a sample of fibre of *Nannorhops Ritchieana* from India.

Report on a comparison of the constituents of Indian and China teas.

Report on a series of samples of Manganese ores from the Central Provinces of India.

Report on samples of Kino from India.

Report on a sample of the resin of *Hopea odorata* from Burma.

Third report on the purity of the opium alkaloids manufactured at Ghazipur.

Report on the rubber of *Parameria glandulifera* from the Andaman Islands.

Report on a sample of Asbestos from India.

Report on a sample of Cotton from Bengal.

Report on Mica from Ajmer, India.

Report on the rubber of *Cryptostegia grandiflora* from Bombay.

Report on Kapok (*Eriodendron anfractuosum*) from Madras.

Report on Hops from Kashmir.

Summaries of the more important of the reports included in the foregoing list have been published during the year in the "Bulletin of the Imperial Institute."

Publications.—During the year the following articles, prepared by the staff of the Scientific and Technical Department of the Imperial Institute and relating especially to Indian natural products, have also been published in the Bulletin :—

"Production of Manganese ore in India," 1905, iii, 81.

"Cultivation of Jute and similar fibres," 1905, iii, 251.

"Poisonous properties of the beans of *Phaseolus lunatus*," 1905, iii, 373.

"Indian Aconites and their poisonous constituents," 1906, iv, 32.

"Mineral Production in India," 1906, iv, 156.

"Production and uses of Oil of Turpentine," 1906, iv, 215.

"Occurrence and uses of Corundum," 1906, iv, 238.

Much information respecting the composition and value of Indian economic products has been supplied to enquirers both in India and in the United Kingdom.

G. I. C. P. O.—No. 24 S. B. S. A.—11-3-1907.—850.—J. M. M.

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Departmental Publications.

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(2) Commercial Circulars printed for circulation but not on sale.
(3) Annual Report of the Industrial Section, Indian Museum.

II.—Meteorological Department.

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Bengal Office.

(1) Bengal Daily Weather Report and Chart.
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Bombay Office.

(1) Bombay Daily Weather Report and Chart.
(2) Monthly abstracts of the Bombay observations (Bombay Gazette)

Madras Office.

(1) Madras Daily Weather Report and Chart.
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Allahabad Office.

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Lahore (Simla) Office.

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(2) Annual Summary } of Punjab weather.

III.—Geological Survey.

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A complete list of the contents of these publications can be obtained by application to the Registrar, Geological Survey of India, 27 Chowringhee Road, Calcutta. Indexes to the Genera and Species described in the Palæontologia Indica up to 1891, to the Memoirs, Vols. I—XX, and to the Records, Vols. I—XXX, have been printed for sale.

IV.—Survey of India.

(1) Annual General Report.
(2) Professional Papers.

V.—Botanical Survey and Royal Botanic Garden, Calcutta.

(1) Annual Report of the Botanical Survey of India.
(2) Records of the Botanical Survey, Vols. I—III, No. 2, and Vol. IV, Nos. 1—3.
(3) Annual Report of the Royal Botanic Garden, Calcutta.
(4) Annals of the Royal Botanic Garden, Calcutta, Vols. I—X.

VI.—Department of Agriculture.

(1) *Annual Report.*—An account of the year's work of the Imperial Department, including the separate reports of the scientific officers of each branch (Agricultural Chemistry, Botany, Mycology, Entomology and the like).

(2) *The Agricultural Journal of India.*—A quarterly journal containing articles on agricultural matters intended for the educated agriculturist and the general reader interested in Agriculture.

(3) *Scientific Memoirs of the Department of Agriculture.*—An occasional publication for papers of a scientific or technical nature divided into series such as Chemical, Botanical, Entomological, and the like.

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VII.—Forest Department.

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(2) *Annual Progress Report of Forest Administration in each Province.* Issued by the Local Governments annually.

(3) *The Indian Forester.*—A monthly journal of Forestry, Agriculture, Shikar and Travel. This is a Departmental Journal published monthly.

(4) Bulletins are published from time to time.

VIII.—Zoological Department.

(1) Annual Report.

(2) Monographs, appearing at irregular intervals.

IX.—Civil Veterinary Department.

(1) Annual Report.

Annual Report of the

Board of Scientific Advice

for India

for the year 1906-07

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1908

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PREFACE.

THE Board of Scientific Advice for India was constituted in 1902, and consisted originally of the heads of the Meteorological, Geological, Botanical, Forest, Survey, Agricultural and Veterinary Departments; but the Government of India intimated their intention to invite from time to time to serve upon it other scientific officers in the service of the Imperial and Provincial Governments, whose special attainments might render their assistance desirable. The Board was declared to be a central authority for the co-ordination of official scientific enquiry, its object being to ensure that the work of research is distributed to the best advantage, that each investigator confines his researches to the subject with which he is most capable of dealing, and that energy is not dissipated by the useless duplication of enquiries or misdirected by a lack of inter-departmental co-operation. It was also hoped that while the claims of abstract science would continue to be recognized in the work of the scientific departments, the Board's advice would aid the Government of India in prosecuting practical research into those questions of economic or applied science, on the solution of which the progressive prosperity of the country, especially as regards its agricultural and industrial development, so largely depends.

The Board advises generally upon the operations of the Departments, with due attention to the economic side of their work, and serves as a reference on all matters connected with the organization of scientific enquiry in India. It annually discusses the proposals of each departmental head in regard to the programme of investigation in his department; and in cases where inter-departmental co-operation is necessary, it advises as to the lines on which mutual assistance should be given and the department to which the enquiry should primarily appertain. It submits annually to the Government a general programme of research, embodying the proposals of departmental heads in so far as its subjects are to be exclusively dealt with in one department, and its own proposals in cases where two or more departments are to co-operate, and at the end of the year it presents a brief review of the results obtained during the year in all lines of scientific investigation controlled by its members. Its reports and programmes are communicated

through the Secretary of State to the Royal Society, who have appointed an Advisory Committee to consider them, and who from time to time furnish the Board and the Government of India with valuable suggestions and advice.

The present members of the Board of Scientific Advice are :

Name.	Appointment.
Mr. R. W. CARLYLE, C.I.E., I.C.S.	Secretary to the Government of India in the Department of Revenue and Agriculture. *Ex-officio* President.
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Captain A. T. GAGE, I.M.S., M.A., B.Sc., M.B., F.L.S.	Director, Botanical Survey of India.
Dr. N. ANNANDALE, B.A., D.Sc.	Superintendent, Natural History Section, Indian Museum.
Mr. S. EARDLEY-WILMOT, C.I.E.	Inspector General of Forests.
Mr. J. W. MOLLISON, M.R.A.C.	Inspector-General of Agriculture.
Colonel H. T. PEASE, C.I.E., I.C.V.D.	Inspector-General, Civil Veterinary Department.
Mr. I. H. BURKILL, M.A., F.L.S.	Reporter on Economic Products to the Government of India.
Colonel S. G. BURRARD, R.E., F.R.S.	Superintendent, Trigonometrical Surveys.
Dr. MORRIS W. TRAVERS, D.Sc., F.R.S.	Director, Indian Institute of Science.

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1. The Surveyor-General of India (Chairman):
2. The Director-General of Observatories;
3. The Director, Geological Survey of India.

Sub-Committee B.—(*Agricultural Products*).

1. The Director, Botanical Survey of India (Chairman);
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3. The Inspector-General of Agriculture.

Sub-Committee C.—(*Soils and Manures*).

1. The Inspector-General of Agriculture (Chairman);
2. The Director, Geological Survey of India;
3. The Inspector-General of Forests.

Sub-Committee D.—(*Forest Products*).

1. The Inspector-General of Forests (Chairman);
2. The Superintendent, Industrial Section, Indian Museum;
3. The Director, Botanical Survey of India.

Sub-Committee E.—(*Veterinary subjects*).

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2. The Director-General of Observatories;
3. The Superintendent, Industrial Section, Indian Museum;
4. Colonel S. G. Burrard, R.E., F.R.S.;
5. Morris W. Travers, Esq., D.Sc., F.R.S.

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ANNUAL REPORT

OF THE

BOARD OF SCIENTIFIC ADVICE FOR INDIA

FOR

1906-07.

SUMMARY OF PROCEEDINGS.

10th Meeting held at Simla on 6th May 1907.

THE Board had first under consideration the remarks of the Advisory Committee of the Royal Society of London on the staff and general scientific work both in the field and in the laboratory of the Imperial Civil Veterinary Department. As the remarks of the Advisory Committee had been referred by the Government of India to the Inspector-General of the Civil Veterinary Department for report the Board resolved to wait for the latter's reply.

The Board then discussed the remarks of the Royal Society's Advisory Committee on zoological subjects, in the course of which the establishment of zoological laboratories and small teaching museums in all the large University Colleges of Northern and Western India and an increase in the permanent staff of the Natural History Section of the Indian Museum were advocated. With regard to this the Board

were given to understand that proposals for an increase in the permanent staff of the Natural History Section of the Indian Museum had been submitted to Government by the Trustees of that Museum.

The comments of the Advisory Committee on the inadequate number of the staff of the Royal Botanic Garden, Calcutta, with regard to the demands of the Botanical Survey of India; on the delay in the publication of certain volumes of the Annals of the Royal Botanic Garden, Calcutta, and on the progress of the proposed Manual of Indian Cultivated Plants were discussed. The Board resolved to accept the report of the Director of the Botanical Survey and to endorse his explanation of the delay in the appearance of certain volumes of the Annals of the Royal Botanic Garden. As regards the Manual of Indian Cultivated Plants the Board resolved to refer the subject to Sub-Committee B to report what form such a Manual should take, the agency by which it should be prepared and what steps could be taken towards making a commencement.

The suggestions offered by the Advisory Committee with regard to a further investigation of Lathyrism in India, the collection of statistics of production by the Forest Department, and the cross breeding of wheat and other crops by the Agricultural Department were considered by the Board, who were informed that the subject of Lathyrism was under the consideration of the Government of India and that the other investigations were already being conducted on the lines suggested.

Correspondence regarding the revision of the Dictionary of the Economic Products of India and the cultivation of Flax in India was read and recorded.

With reference to a letter from the Government of India regarding the systematic examination of small mammals likely to act as carriers of plague infection the Board were informed that a pamphlet on the subject would shortly be issued under the supervision of the Superintendent of the Natural History Section of the Indian Museum.

The programmes of work for 1907-08 of the various scientific departments were discussed. The Board resolved to ask the Inspector-General of the Civil Veterinary Department to draw up a revised programme of the work to be done at Muktesar with regard to the remarks of the Advisory Committee of the Royal Society. The programmes of the other departments with minor emendations were recommended for acceptance by Government.

The Board resolved to suggest to the Government of India that Dr. Morris W. Travers, D.Sc., F.R.S., Director of the Indian Institute of Science, should be invited to serve upon the Board.

11th Meeting held at Calcutta on the 20th December 1907.

After formal business was transacted the Board had under consideration a letter from the Government of India with enclosures embodying a report by the Director of the Botanical Survey of India with comments by the Director of the Royal Botanic Gardens, Kew, on the proposed reorganisation of the Botanical Survey of India. The Board resolved to refer the question to a special Sub-Committee consisting of the Director of the Botanical Survey of India, the Superintendent of the Industrial Section, Indian Museum, the Inspector-General of Agriculture and the Director of the Geological Survey of India for report to the Board at the next meeting.

A letter from the Government of India regarding the future organisation of the Economic Products Department and a memorandum by the Reporter on Economic Products on the same subject were read. The Board resolved to refer the subject to a special Sub-Committee consisting of the President of the Board of Scientific Advice, the Secretary to the Government of India in the Department of Commerce and Industry or an officer to represent him, the Inspector-General of Agriculture, the Inspector-General of Forests, the Superintendent of the Industrial Section, Indian Museum, the Director of the Botanical Survey of India and the Director of the Indian Institute of Science for report to the next meeting of the Board.

Endorsements from the Government of India forwarding correspondence on the subject of the proposed revision of the Dictionary of the Economic Products of India, on meteorological subjects and on veterinary subjects were read and recorded.

The draft Annual Report of the Board for 1906-07 was then considered. It was resolved that after certain alterations in the various sections of the report it be approved of and that each contributor should be supplied with 50 copies of his contribution.

The distribution list of the Annual Report was then read and the additions and alterations suggested by the Board noted.

A further report of Sub-Committee D (Forest Products) on the manufacture of wood-pulp for paper making and a note by the Director

of the Geological Survey of India on the investigation into the movement of glaciers were read and recorded.

Proposals by the Director of the Geological Survey of India for the investigation of the origin of salt in Rajputana were read. The Board approved the proposed investigation and expressed the opinion that the subject should be referred to the Geological Survey Department.

Proposals by Dr. M. W. Travers and Mr. T. H. Holland for the institution and reform of Scientific Libraries in India were read and the Board resolved to appoint an additional permanent Sub-Committee F to deal with such questions. This Sub-Committee to consist of the Director of the Geological Survey, Chairman; the Director-General of Observatories, the Superintendent of the Industrial Section, Indian Museum, Colonel S. G. Burrard, R.E., and Dr. Morris W. Travers.

ANNUAL REPORT FOR 1906-07

INDUSTRIAL AND AGRICULTURAL CHEMISTRY

BY

J. W. LEATHER, PH.D., F.I.C., F.C.S.,
Imperial Agricultural Chemist,

AND

D. HOOPER, F.C.S., F.I.C.,
Curator, Indian Museum.

India-rubber.—Considerable interest is still being manifested in rubber secretions yielded not only by cultivated trees, but also by wild plants of all kinds that appear to yield a caoutchouc-like latex. Samples of finished rubber from the Para rubber (*Hevea brasiliensis*) plantation at Mergui have been examined with very satisfactory results. In connection with these plantations, Mr. E. P. Stebbing has investigated the life history of *Termes Gastroi*, the Hevea rubber termite, with a view to combat its ravages. In the nest of this termite, there is usually found a mass of rubber either as a result of a natural flow of the latex following upon the wounding of the trees by the insects or by the abnormal exudation due to a previously diseased condition of the tree. A sample of this rubber was submitted to analysis and it was found to be exceptionally pure, containing 96·7 per cent. of caoutchouc. It would appear that the termites had reduced the proportion of resins by consumption or by some chemical process of separation in the crude latex.

Further investigations have been made of the latices of wild Indian fig trees, but none of the samples, so far, approach in composition the superior quality of the secretion of *Ficus elastica*. The five samples of the following species contained large quantities of resinous constituents, and a caoutchouc content as indicated:—*Ficus tomentosa* 31·2; *F. retusa* 24·1; *F. bengalensis* 21·4; *F. Rumphii* 12·6; and *F. glomerata* 4·9 per cent.

The latex of *Streblus asper*, called "On hue" in Burma, is of a similar character. The latex afforded 25 per cent. of solid crude rubber which consisted of 22·9 per cent. of caoutchouc, 76·5 per cent. of resins and 0·6 per cent. of ash.

Pontianak, the gutta of *Dyera costulata* (W. A. Tilden, *Chem. News*, 1906, 94, 102). The latex yields 44 per cent. of solid matter, almost completely soluble in alcohol and in acetone. The caoutchouc is mixed with two or more other substances of which one, melting at 173°, is crystalline, and contains 81·2 per cent. of carbon and 11 per cent. of hydrogen, corresponding approximately to the formula $C_{14}H_{22}$. P. van Romburgh (*Proc. K. Akad. Wetensch.*, 8, 1906, 137) found lupeol to be a constituent of this gutta-percha.

Gum and Resins.—The oleo-resin of *Hardwickia pinnata*, a tree of Tinnevelly, South Kanara and Travancore, has been examined by D. Hooper (*Pharm. Journ.*, LXXVIII, 4). Two authentic samples from South India were tested as to their composition, and their physical and chemical constituents determined. The properties of this exudation are sufficiently characteristic to distinguish it from copaiba balsam and gurjun oil (*Dipterocarpus turbinatus*).

The gum resin of the mango tree (*Mangifera indica*) has for the first time been analysed and definitely described (*Pharm. Journ.*, LXXVIII, 718). It is a resinous gum containing about 79 per cent. of resin and 15 per cent. of arabinoid gum. Museum samples differ much in their composition, a fact which throws doubt upon the authenticity of their origin.

H. H. Robinson has examined the gum of *Cochlospermum Gossypium* (*Proc. Chem. Soc.*, 22, 314). By hydrolysing the gum with water a dibasic acid of the formula $C_{23}H_{36}O_{21}$ was obtained, for which the name gondic acid is proposed. Two sugars were also separated, one xylose, and the other a hexose, possibly galactose. A colloid substance, α-cochlosperminic acid, was also present. The original gum yielded 14 per cent. of acetic acid.

Oils and Oil-seeds.—The chemical composition of the chief oil-seeds of India has been detailed by Dr. J. W. Leather (*Memoirs Dept. of Agriculture in India*, Chemical Series, 1907, I, 13—38). The analyses have been made by the usual methods except in the determination of the oil, in which, after the bulk had been extracted with ether the residue was dried in the air, crushed again, and once more extracted The list of seeds which have been examined includes:—Earthnut (*Arachis hypogæa*), Mowha (*Bassia latifolia*), Sarson, Toria and Rai (*Brassica spp.*), Safflower (*Carthamus tinctorius*), Taramira (*Eruca sativa*), Cotton seed (*Gossypium*), Niger seed (*Guizotia abyssinica*),

Linseed (*Linum usitatissimum*), Poppy (*Papaver somniferum*), Castor (*Ricinus communis*), Til, jinjilly (*Sesamum indicum*).

Babu S. N. Dey (*Agricultural Ledger*, No. 5 of 1906) records the analyses of the seeds, oil-cake and oil of the silk-cotton tree (*Cochlospermum Gossypium*). The seed forms a nutritious food for cattle. The oil which occurs to the extent of 14 to 15 per cent. in the seeds occupies an intermediate position between a semi-drying and non-drying oil.

The seeds of the candlenut tree (*Myristica canarica*) of the Western Coast, after being powdered, are pressed into bamboos and made into candles. The seeds contain half their weight of fat, melting at 39°C. The fat saponifies with great facility, yielding 92 per cent. of crystalline fatty acids, melting at 41°. By crystallisation from alcohol, crystals of myristic acid were obtained showing that the fat consists largely of myristicin. The seeds and mace of *M. malabarica* yield considerable quantities of a similar fat which might be utilised for technical purposes. (Hooper in *Agricultural Ledger*, No. 3 of 1907.)

In a paper on "Fats of Garcinia species" (*Journ. and Proc. Asiatic Society, Bengal*, Vol. III, No. 5, 257-259), D. Hooper gives the results of examinations of fatty oils of *G. Morella* and *G. indica*, trees of Mysore and Bombay, respectively. While the constituent parts of these two fats are almost identical, the interesting fact is elucidated that in *G. indica* the olein is present in the proportion of one to two of stearin, forming olco-distearin; while in the fat of *G. Morella* the olein is present in the proportion of two to one of stearin, forming stearo-diolein.

In a preliminary note on the chemical examination of the milk and butter-fat of the Indian buffalo, E. R. Watson (*Journ. and Proc. Asiatic Society, Bengal*, Vol. II, No. 7, 1906, 293) has shown in what respects the constituents differ from those in cow's milk. From the crystalline form, taste, optical rotation, molecular weight and behaviour with Fehling's solution, the sugar of buffalo milk is identical with lactose. The butter-fat consists of the glycerides of the following acids in the proportions named:—butyric 4·83 to 5·52, caproic 0·37 to 0·42, oleic 30·4 to 41·7, palmitic and stearic acids 46·6 to 57·9 per cent. Compared with the butter-fat of the Egyptian buffalo and the European cow the percentage of volatile fatty acids in the Indian fat is very high. This is probably the best criterion for Indian buffalo fat. In the latter

product the volatile fatty acids are almost entirely butyric. The ratio between the butyric and caproic acid is $\frac{1}{1}^{3}$ for the Indian buffalo, $\frac{4}{1}$ for the Egyptian buffalo and $\frac{8}{2}$ for the European cow. These results, if confirmed by further analyses, should prove of the greatest use in recognising Indian buffalo fat in chemical analysis.

In a paper on Annamese bees wax by J. Bellier (*Ann. Chem. anal. appl.*, 1906, 11, 366-368), it is interesting to observe that this product differs from that of Europe, and closely approximates with the characters of the wax of *Apis dorsata* from British India. (*See Agricultural Ledger*, No. 7 of 1904.)

Regarding the aromatic grass oils, opinion has differed greatly as to whether the two rusa grasses "Motia" and "Sofia" are different varieties, or one and the same plant in different stages of maturity. A further contribution has been made to this topic during the year in the collection in the Nimar district of the Central Provinces of specimens of the two plants together with the essential oils belonging to them. The samples were forwarded by the Reporter on Economic Products to Messrs. Schimmel & Co., of Leipzig, for comparison with other grass oils. The examination resulted in the interesting fact that the oil distilled from "Motia" was a palmarosa oil, and the other one a ginger grass oil. Both distillates possessed the odours characteristic of the respective oils, and by these means could be readily distinguished from each other. The chemical analysis at once showed a great difference between the two oils. The ginger grass oil from the "Sofia" plant agreed completely with one thoroughly examined before, and it would probably have the same chemical composition. The plants were submitted to Dr. Stapf, who declared that they could not be distinguished morphologically, but both belonged to the narrow-leaved form of *Cympopogon Martini* Stapf.

Further researches on East Indian sandal wood have been conducted. F. W. Semmler and K. Bode (*Ber.*, 1907, 40, 1124-1145) fully describe santalol prepared by saponification and fractionation of the oil as well as its alcoholic constituents.

Dyes and Tans—Indigo.—The accurate estimation of the amount of indigotin in commercial indigo has been the subject of four communications in the past year. Messrs. Bergtheil and Briggs after considering various methods already in use, and after testing those which possess any claims to precision, conclude that indigotin is

most accurately estimated by heating the indigo with concentrated sulphuric acid so as to form the disulphonate; water is then added, together with some freshly precipitated barium sulphate. The indigotin is estimated in an aliquot part of the clear solution by potassium permanganate. For the estimation of the indigotin in plant leaf a modification of Rawson's method is considered accurate. To the aqueous extract of the leaf hydrochloric acid and ammonium persulphate are added, but with the precaution of avoiding any serious excess of the persulphate. The precipitated indigotin is filtered off and the indigotin estimated as described above. Messrs. Bergtheil and Briggs find that the impurities present in indigo influence the accuracy of the permanganate method to a serious extent; they find that the precipitation of these by addition of barium chloride (Rawson's method) or calcium carbonate (Grossmann's method) occasions a co-precipitation of the disulphonate. (*Vide Journal of the Society of Chemical Industry*, 25, 729.)

Mr. W. P. Bloxam, having also tested the various methods in use, finds it most accurate to prepare the tetra-sulphonate by heating with fuming sulphuric acid, formation of the potassium salt from this, which is washed free of impurities and then dissolved in hot water and titrated either with permanganate or titanium chloride. Mr. Bloxam shows the amount of indigotin found in specimens which he took from India in 1904, and from these figures he calculates the amount of indigotin which was originally in the leaf. Finally assuming that the indigo leaf originally contained exactly ·6 per cent. of indigotin, he concludes that the efficiency of the process as used in Behar varies from 12·5 per cent. to 50 per cent. It is needless, however, to point to the uncertainty of the premises adopted. (*Vide Journal of the Society of Chemical Industry*, 25, 735.)

These views have been combated on both sides. On the one hand, Messrs. Orchardson, Wood and Bloxam produce evidence that Rawson's method as used by Bergtheil and Briggs yields too high results, and publish also information regarding some of the characteristics of indigo-gluten, indigo-brown and indigo-yellow. Some work was also done on the enzyme of the indigo plant leaf and on the use of Baeyer's condensation of indoxyl and isatin for the estimation of indigotin in the leaf. (*Journal of the Society of Chemical Industry*, 26, 4.) On the other hand, Bergtheil and Briggs, in a subsequent paper, criticise

Bloxam's tetra-sulphonate method and produce evidence that it yields too low results. (*Journal of the Society of Chemical Industry*, 26, 182.) Rawson has also published a paper in support of Bergtheil and Briggs' method and criticises Bloxam's adversely. (*Journal of the Society of Dyers and Colourists*, 1906, 22, 306.)

Important papers on some constituents of natural indigo have also been published by A. G. Perkin and W. P. Bloxam. Part I is concerned with an investigation of the constituents of natural indigo, known under the name of "indigo brown." Crude Bengal indigo was freed from "indigo gluten" by boiling with dilute hydrochloric acid, and the "indigo brown" extracted by boiling pyridine. After removing small quantities of indirubin by acetic acid, this substance, after drying at 100°C., had the composition corresponding to the formula $C_{16} H_{12} O_3 N_2$, and its properties closely resemble those of indigo brown of Berzelius and the indihumin of Schunck. It is probably a complex indoxyl derivative. Small quantities of two other brown compounds were isolated, closely resembling the first mentioned compound. Bloxam's statement that indigo contains a non-nitrogenous red substance could not be confirmed; the only red substance was indirubin. Part II. Indigo yellow.—Rawson has drawn attention to the existence of a peculiar yellow compound in Java indigo from *Indigofera arrecta*, and Bergtheil detected a small quantity of the same compound in indigos made at Pusa from the same plant. From a sample of Java indigo the author isolated a yellow compound and identified it as kampferol, $C_{15} H_{10} O_6$. Kampferol is contained in the plant in the form of a glucoside, kampferitrin. A determination of the yield of kampferol from a sample of the air-dried leaves showed that they contained about 4 per cent. of the glucoside.

In a paper on Indican by A. G. Perkin and W. P. Bloxam (*Chem. Soc. Proc.* 1907, 23, 116-117) the isolation of this glucoside from *Indigofera sumatrana* and *I. arrecta* is shown to be effected by a simple method devised by the authors and its properties are described.

Datisca.—A. Korozynski and L. Marchlewski (*Anz. Akad. Wiss. Krakaw.*, 1906, 95-101) have made a study of the colouring matter of the root of *Datisca cannabina* from fresh material obtained from the Punjab and forwarded through the Reporter on Economic Products. A glucoside was obtained as a yellowish-white material melting at 190°C. The product was hydrolised yielding a sugar and a compound, $C_{15} H_{10} O_6$,

named datiscetin. Datiscetin contains four hydroxyl groups, yielding tetra-acetyl and tetra-benzoyl derivatives. It is isomeric with luteolin and fisetin, and is probably a flavone or flavonol derivative; on heating with alkalis it yields phenol and salicylic acid.

Tanning materials.—During the year an Agricultural Ledger (No. 3 of 1906) has been published dealing with the chemical composition and trade forms of cutch, the extract of the wood of *Acacia Catechu*. The analyses are given of over sixty samples of extract from different parts of India and Burma, and the results are compared with those of gambier and other tanning materials. A method of detecting adulteration in catechu is to separate the extract obtained by means of alcohol of 90 per cent. A good quality of catechu should yield 70 per cent. of extract and upwards, and a fair quality 60 to 70 per cent., while 50 per cent. or less should be regarded as very inferior. The ash limit of 5 per cent. should exclude all worthless specimens, since the mineral constituents of a large number of samples of Burmese cutch averaged only 2·9 per cent.

Medicinal Products.—Dr. Chuni Lal Bose (*Calcutta Medical Journal*, September 1906) has examined the fruits of the bitter variety of *Luffa ægyptiaca* Mill. They contain two toxic glucosidal principles, one of which is soluble and the other insoluble in chloroform. The former is a severe emetic with only slightly irritant properties in the bowels, while the latter seems to possess no emetic properties, but causes irritation in the lower bowels giving rise to dysenteric symptoms. The latter, from its chemical behaviour and its physiological action, closely resembles colocynthin. No alkaloids were obtained from the fruits. Messrs. Naylor and Chappel have isolated from the fruits of *Cucumis trigonus* Roxb., a bitter glucosidal principle apparently identical with colocynthin.

As everything relating to jute is of interest to India, the investigation of the toxic glucosides in certain jute seeds by R. Kobert (*Sits. Ber. naturf. Ges.* Rostock, 1906. *Apoth. Zeit.*, 1907, 22, 179) should be referred to. The seeds of *Corchorus fascicularis* are mucilaginous, sweet, non-toxic, and edible; those of *C. olitorius* are purgative; those of *C. capsularis*, *C. bengalensis*, *C. acutangulus*, *C. argutus* and *C. trilocularis* contain fat; and the last three, besides a green fluorescent body, a toxic glucoside, the corchorin of Tsuno

and W Friboe. Corchorin is very poisonous being allied to the digitalis glucosides.

Ipomœa Turpethum.—(E. Votocek and J. Kastner *Apoth.*Zeit.*, 1907, 22, 259). The authors find that besides turpethin, the resinoid body insoluble in ether, the rhizome contains a previously undescribed glucosidal resin now named turpethein, soluble in pure ether.

Samples of Hops (*Humulus Lupulus*) grown in Kashmir have been examined in the Industrial Section of the Indian Museum and were found to yield 13·2 and 12·9 per cent. of oleo-resin by Coez's benzol method. The yield is thus not far below that of North French hops of commerce.

Food stuffs.—Tubers called Singapuri keshur are sold as a vegetable in the Calcutta market. They have been determined as the roots of *Eleocharis tuberosa*, and have been analysed in the Indian Museum. They are composed of water 4·34; fat 0·71; albuminoids 8·12; carbohydrates 77·47; fibre 3·70; and ash 5·66.

The seeds of *Phaseolus lunatus*, "Pois de Java," have been analysed by E. Kohn-Abrest (*Comptes rend.*, 1906, 142, 586-589). The seeds yield hydrogen cyanide on macerating with water and subsequent boiling with hydrochloric acid. In eight varieties the amounts varied from 0·523 to 1 638 grms per kilo. Cold dilute hydrochloric acid only liberates very small quantities of hydrogen cyanide.

Tea.—A second paper on the fermentation of tea has appeared in which Dr. Mann recapitulates the results of experiments regarding the effects of several additional factors.

In the previous paper he produced evidence in favour of a temperature of 78—82° F. during fermentation and opposed to a higher one than 84° F. Dr. Mann now adds similar evidence showing that a temperature below 75° F. causes the process to be unduly protracted and occasions a loss of flavour. Regarding *flavour*, which is attributed to an essential oil, the experiments go to show that it is not increased during the withering process, but that during rolling it is rapidly formed and a further increment occurs in the earlier part of the fermentation. The maximum "flavour" is attained in about three hours. On the other hand, for the production of a maximum "thickness of liquor" a period of more than four hours is necessary. Two other points are dealt with, the one being the large amount of oxygen absorbed by the leaf during fermentation, 4·5 lbs. having abstracted the oxygen

from 1 c. ft. of air, and the consequent necessity for ventilation is emphasised; the other, the necessity for rapid drying of the fermented leaf.

Alcoholic Liquors.—An excellent report has been published by Major C. H. Bedford on the quality, manufacture and excise control of alcoholic liquors in India, the memorandum being an official summary of the work done in the Central Excise Laboratory, Kasauli. The manufacture of country spirit is fully described and numerous tables are given showing the strength and composition of potable spirits prepared at different localities and under varying conditions. In a paper read before the Society of Chemical Industry, entitled "The Determination of Higher Alcohols in Spirits" (*Journ. Soc. Chem. Ind.*, XXVI, 1907, 123-126), Messrs. Bedford and Jenks discuss the usual analytical methods employed for estimating amyl, normal butyl, isobutyl, normal propyl and isopropyl alcohols constituting the higher alcohols in ethyl or ordinary commercial alcohol. The Allen-Marquardt process is an accepted one and was adopted for the purposes of the inquiry. While amyl alcohol by itself can be determined by this method with a high degree of accuracy, the intermediate alcohols are also returned with notably low results. In the present paper the authors publish their methods for extracting the whole of the higher alcohols from spirituous liquors, and describe the ester-iodine method for rapidly determining them in the extract.

"Available" plant food in Soils.—Some attention has been given to this subject in the Chemical Section of the Agricultural Research Institute and the results of three years' work were recently published as a Memoir of the Department (Chemical Series, Vol. I, No. 4). The primary object was to check the value of Dyer's method on a variety of Indian soils by means of Pot-Cultures. Eight soils were so tested and the experiments supported the value of the method. At the same time it is to be recognised that there is much need to perfect our methods in this direction and it consequently continues to be a subject for investigation.

Soil Moisture.—This subject has been taken up at the Agricultural Research Institute, Pusa, in part because so little is at present known about the actual amount of water which is present in soils, and still less regarding the rate at which loss of water occurs during dry weather, or of the distance through which water moves during these

periods ; in part because information on these points in respect of water would provide an index regarding the movement of plant foods or injurious salts.

The data obtained during the first year are about to be published as a Memoir of the Agricultural Department. The following are briefly the deductions which have been made :—

(*a*) Water is lost from a soil from a limited depth only ; this depth increases with the period of time involved ; it is assumed that it will vary with the nature of the soil, though, since the work was done on only one soil, experimental proof is required of this.

(*b*) The rate of loss of water depends in part on atmospheric temperature and humidity ; in part on the quantity of water present in the soil, *i.e.*, it follows the " compound interest law." Consequently the loss is greatest immediately after rain and decreases with the time. This explains why the amount of loss by evaporation has been found at Cawnpore to be so little in excess of that recorded at Rothamsted. The former is apparently about 17″ per annum, the latter about 14″.

(*c*) The greatest distance which water was found to move at Pusa during the approximately dry period of nearly nine months was somewhat more than three feet. The drying effect was experienced to a depth of seven feet.

(*d*) It is commonly stated that the water-holding and water-retaining capacity of the soil depends on its " physical character." Whilst credence may very properly be given to this statement, it is devoid of any sense of precision and an attempt is being made to determine those particular physical characters which control retention of water. In the past year the connection between ability to retain water with the surface possessed by the soil particles has been studied, and a general relationship established ; but it is too early to form an opinion as to whether success will be achieved in this direction. It is intended to extend the observations on the retention of water and maintain records at three other places in the Indo-Gangetic alluvium, in order to include a greater

variety of conditions of soil and climate respectively than can be obtained at Pusa.

Arabian well waters.—An examination has been made of samples of well-waters from the Hadhramaut Coast. The water issues from subterranean lakes and possesses great fertilising properties especially conducive to the cultivation of a high grade tobacco. The saline constituents of the water consist chiefly of alkaline sulphates with only minute quantities of nitrates.

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ASTRONOMY

BY

G. T. WALKER, M.A., Sc.D., F.R.S.,
Director-General of Observatories.

Solar Physics.—Research in solar physics is carried on under the direct control of the Government of India at Kodaikanal, the Director being Mr. Michie Smith. The staff received a large increase of strength when Mr. J. Evershed took over his duties as Assistant Director in January last. Since 1st April 1907, Mr. Michie Smith has been away on leave. The chief instruments are :—

(*a*) A spectroheliograph made by the Cambridge Scientific Instrument Company, the object of which is that of making photographs of the sun using the light emitted by one chemical element only.

In this apparatus a stationary image of the sun is made by a 12-inch triple-achromatic lens of 20-foot focus fed by an 18-inch Foucault siderostat. Close up to the image and somewhat longer than its diameter is the narrow vertical slit of a spectroscope arranged in such a manner that the light which has passed horizontally through the collimating lens shall be deflected through two right angles by two prisms and a mirror, and so emerge from the camera lens parallel to its original direction. This light then falls upon another vertical slit which can be adjusted in such a position as to allow light of any desired wave length to pass through. In the Kodaikanal spectroheliograph the collimating and camera lenses, each of 5-inch aperture and 6-foot focal length, together with the prisms and slits, are attached to a rigid framework, while immediately in contact with the slit last described is a stationary photographic plate within a fixed camera. The rigid framework is capable of motion in a horizontal plane in such a manner that the primary slit may pass uniformly across the image of the sun while the secondary slit will move at an equal rate across the sensitised plate; and

as in each position an image will be formed at the second slit by light of the desired wave length and no other light can emerge, the result of the movement upon the plate is a complete image of the sun in monochromatic light. At present the H and K lines of calcium are largely used on account of the convenience afforded by the width of their absorption shading and the fact that the centre of the dark line is frequently 'reversed,' *i.e.*, is bright instead of dark, indicating that the calcium vapour is abnormally hot in the higher levels of the solar envelope. A photograph so obtained shows bright clouds—called 'flocculi'—of calcium vapour scattered about over the sun and gives a large amount of information that is not otherwise obtainable. Further, by causing the slits to move more slowly the exposure may be lengthened sufficiently to give photographs of the 'prominences' projecting from the sun's margin.

This instrument has been completely overhauled during the year and various devices for improving the definition have been adopted, including a diminution of the amount of exposure to sunlight of the ground near the instrument and the removal of a very stiff spring inside the 12-inch lens. The result of the changes has been very satisfactory.

(*b*) Two 6-inch refractors, with one of which an Evershed spectroscope has been used since November 1904.

These are used for visual examination of the sun and for spectroscopic study of spots and prominences.

(*c*) A spectrograph consisting of an 11-inch polar siderostat with a 6-inch Grubb lens of 40-foot focus. This is used with a 4-inch concave grating of 10-foot focus mounted on Rowland's plan, or a parabolic grating collimated to cure astigmatism, or a plane grating with collimator and camera lenses of 8-foot focus. A powerful spectrograph has also been erected in the spectroheliograph room, using a 3-inch plane grating. It is employed in photographing the ultra-violet region in spot spectra and in studies on the line of sight movement of the chromospheric gases. Both spectrographs have been fitted with

special occulting shutters for regulating exposures in spot spectrum work.

(*d*) A photoheliograph by Dallmeyer. With this a photograph of the sun in ordinary light is made daily when possible. Originals are sent to Greenwich for the use of the Solar Physics Committee for those days for which photographs are not available from Greenwich or Dehra Dun.

2. In addition to the use of the spectroheliograph and photoheliograph the routine work includes visual examination of sunspots and faculæ, observations of widened and displaced lines in sunspot spectra and spectroscopic observations of prominences. A monthly article describing the solar activity is contributed to the "Monthly Weather Review," while for more technical purposes bulletins of the observatory are issued. Of these eleven have appeared, the last including the spectroscopic observations of sunspots down to the end of February 1907.

The scope of the work has been enlarged during the year by the use of the parabolic grating in connexion with the 40-foot spectrograph and the bringing of this instrument into constant use in the study of spot spectra. Photographs are now made in which different exposures are given for the spot and for the adjacent photosphere in order that equally dense images of both spectra may be obtained: these are then copied and enlarged with a special apparatus so as to bring out the characteristic features of the spot spectrum with the greatest clearness. Estimates of the amounts of intensification or of enfeeblement of the lines in spots can thus be satisfactorily determined. Detailed measurements of the characteristic spot bands in the neighbourhood of "b" have been made in co-operation with Professor Fowler with a view to the careful comparison of their positions with the bands of magnesium hydride. Photographs have also been obtained showing a considerable number of affected lines in sunspots in the violet and ultra-violet regions of the spectrum.

One of the more interesting of the year's results has been the identification of dark markings in the spectroheliograms with prominences seen in projection on the disc.

The observatory is now co-operating with the "International Union for Solar Research."

There is also at Poona, under the Government of Bombay, the Takhtasingji Observatory, where research in solar physics is carried on by Mr. Naegamvala. The chief portions of the equipment are:—

(*a*) A Foucault 12-inch siderostat with an 8-inch image lens and a spectroscope with a 1½-inch Rowland grating. With these daily observations are made of the twelve most widened lines in sunspot spectra in the region D-F. The results have been forwarded monthly to Sir Norman Lockyer, and very close agreement of these observations with those at South Kensington has been attained. The appearance of the line D_3 and reversals of C and F are also noted whenever observed. Proposals for an improvement in the equipment are under consideration.

(*b*) An equatorial refractor with a Cooke 6-inch triple photo-visual lens. This is provided with two 45° objective prisms, and a prominence spectroscope with a Thorpe transmission grating has been constructed locally for attachment to it.

(*c*) An equatorial reflector with a 20-inch mirror by Common. A focal plane spectrograph had previously been received from Sir H. Grubb, but repairs to the dome had prevented the telescope from being mounted. When this was done alterations in the mounting of the mirror were found necessary and these have only recently been completed.

The observatory has also undertaken to assist in the scheme for the observation of sunspot spectra drawn up by the "International Union for Solar Research."

Solar Radiation.—The equipment at Simla for measuring solar radiation consists of two Angstrom pyrheliometers which arrived from England in October 1906 and a third, presented to the department by Dr. Sven Hedin, which arrived at the end of May 1907.

At Calcutta there is a Callendar radiation recorder.

The object for which the observations are made is that of determining the nature and amount of the changes in the radiation given off by the sun, rather than the amount of it which reaches the earth: and experience has shown that the difficulties are by no means easy to overcome. A trace of cloud, or of smoke from the neighbouring

bazaar, which may be so faint as to be scarcely perceptible to the eye, is sufficient to diminish materially the reading of the instrument; and at certain times of year the observations are rendered practically useless either by the dust which rises from the strongly heated ground or by currents of air from which it is difficult to protect the instrument without modifying the radiation to which it is subjected. In June for example the radiation on apparently clear days, as measured, is distinctly less than in November and December, although in the latter case the zenith distance of the sun is about 54° as compared with 8° in June. Of the two instruments sent from England, one was slightly deranged in transit and the arrangements for instituting comparative observations at Roorkee are in consequence not yet carried out.

The approximate values of the radiation as measured at Simla during the various months have been, in gramme calories per minute per square centimetre,—

November 1906 . .	1·49
January 1907 . . .	1·49
March	1·55
April	1·51
May	1·40
June	1·32
November . . .	1·44

METEOROLOGY

BY

GILBERT T. WALKER, M.A., Sc.D., F.R.S.,
Director-General of Observatories.

Study of Seasonal Variations of Climate.—The statistical methods which were employed last year have been applied to additional data and have confirmed the general character of the results previously obtained. It has for instance been shown that the high pressure in the Argentine Republic which is associated with numerous sunspots extends to Honolulu and to Washington; and further that the general tendency for pressure relationships with abundant Indian monsoon rainfall to be similar to those with numerous sunspots holds good for Honolulu, but probably not for Washington.

In view of the fact that the department was founded as late as 1875 it is only for 32 years that reliable data of most of the Indian meteorological elements are available. This is somewhat short for trustworthy inferences as to causal relationships and an attempt has been made to push the limit further back. In pressure this can be done: for the mean of the annual pressure departures at Calcutta, Bombay and Madras is practically identical with that of India, and the data of the three stations extend back to 1855. For rainfall a backward extension is more difficult: actual tabulation shows very material differences between the result given by 50 well distributed stations and that of 2,500 stations, while the result of 450 stations also differs appreciably from the latter. It is therefore impossible to place confidence in conclusions drawn from stations fewer than 50 and decidedly irregular in their distribution. For most purposes therefore it may be said that the rainfall of India as a whole begins to be trustworthy at about 1865 and is not accurately known before 1875. This view is supported by what is known of the earlier famines and also by the fact that the relationships of rainfall with sunspots and some other factors as deduced from the earlier years are different from those given by the later years.

Statistical methods show that of the data which are available at the beginning of June those which are most closely associated with abundant rainfall in the ensuing monsoon are low pressure at Mauritius in the previous May, high pressure in the Argentine Republic and Chili in the period March to May, deficient subequatorial rainfall in May as given by Zanzibar and Seychelles, deficient snowfall in May, and high pressure in India during the previous year.

When estimating the most likely quantity of monsoon rainfall the resultant effect of these cannot be obtained by adding their separate effects, for they are not independent of one another. Using the phrase 'correlation coefficient' of two mutually dependent quantities with its ordinary meaning of the proportionate extent to which the variations of either are governed by those of the other, * the mutual

* Thus if the factors are independent the coefficient is zero, if they always move by exactly proportionate amounts either increasing or decreasing together it is +1, and if by exactly proportionate amounts in opposite directions it is —1. If one half of the variations of one quantity are governed by those of the other and the remaining half by accidental circumstances the coefficient is ½.

influence of the previously mentioned quantities and of the monsoon rainfall of the previous year are indicated in the following table in which the correlation coefficient between two quantities is to be found at the intersection of the row and the column corresponding to them :—

—		Maur. pressure.	S. Amer. pressure.	Subeq. rain.	Snow.	Press. prev. yr.	Rain prev. yr.
Monsoon rain .		—·45	+·55	—·25	—·40	+·35	0
Maur. pressure .		+1·00	—·15	+·25	+·05	—·45	+·25
S. Amer. press. .		—·15	+1·00	0	—·60	+·10	+·35
Subeq. rain .		+·25	0	+1·00	+·45	+·15	+·05
Snow . .		+·05	—·60	+·45	+1·00	+·15	—·30
Press. prev. yr.	+·35	—·45	+·10	+·15	+·15	+1·00	—·55
Rain prev. yr. .	0	+·25	+·35	+·05	—·30	—·55	+1·00

It must be remembered that owing to the fewness of the years which are available the probable errors in this table vary from ·09 to ·12.

From this there follows by ordinary statistical methods—

$$\left\{\text{Monsoon rain}\right\} = -\cdot2\left\{\text{Maur. pressure}\right\} + \cdot4\left\{\text{S. Amer. pressure}\right\}$$
$$-\cdot2\left\{\text{subeq. rain}\right\} - \cdot1\left\{\text{snow}\right\} + \cdot3\left\{\text{press. prev. yr.}\right\}.$$

where the equation connects the proportional departures of the quantities within brackets, the proportional departure being the ratio of the actual departure to its mean value over the series of years. If this formula be applied to the data of the successive years in the past the

calculated departures of monsoon rainfall are those contained in the following table together with the actual departures:—

Year.	Rainfall departure.		Year.	Rainfall departure.	
	Calculated.	Actual.		Calculated.	Actual.
1875	+1·8	+4·4	1891	−3·4	−2·9
1876	−3·5	−2·5	1892	+3·6	+4·9
1877	−4·6	−7·1	1893	−0·5	+3·6
1878	+2·3	+2·8	1894	+2·9	+4·7
1879	+2·4	+2·3	1895	+0·8	−2·7
1880	+0·2	−1·7	1896	+1·6	−1·1
1881	−1·5	+1·8	1897	−2·1	+0·4
1882	+1·2	+2·2	1898	+0·3	+0·6
1883	−1·5	−1·3	1899	−3·9	−7·0
1884	−1·4	+2·2	1900	−0·2	+1·1
1885	+0·7	+0·4	1901	+0·7	−4·6
1886	+2·6	+0·9	1902	−1·3	−1·6
1887	+1·4	+1·4	1903	+0·4	−0·3
1888	−1·8	−0·4	1904	−1·0	−2·2
1889	+3·6	+2·3	1905	−1·5	−2·9
1890	+2·3	+1·8	1906	−1·2	−0·1

It will be seen that the rainfall departures as forecasted by the formula agree on the whole moderately well with the actual departures; and the correlation coefficient of the calculated and actual proves to be ·7. If we consider the 24 years in which the forecasted departure exceeds 1″ the question of excess or defect in the subsequent monsoon is rightly indicated in 20 cases and wrongly in 4 cases. It has unfortunately happened that this year's monsoon with a calculated excess has had an actual deficit of 3·1″. Curiously enough the pressure in South America and the Indian Ocean have remained extremely

favourable on the whole, and it seems necessary to attribute the early withdrawal of the monsoon to some important factor that is at present unknown.

Among the details which have been ascertained during the year may be mentioned a remarkable relationship between pressure at Mauritius and the position of the trough of low pressure in Upper India during June, July and August : if the former pressure rises the trough tends to move a few days afterwards towards the foot of the Himalayas, and *vice versâ*. The connection was close enough this year to enable the rises and falls in the weekly pressure at Mauritius to be inferred from the daily weather maps in at least three cases out of four.

Meteorological charts of the Indian Ocean. Owing to the kindly cooperation of the meteorological offices at London, Washington, Hamburg and Mauritius, originals or copies of ship's logs have been secured in addition to those obtained by departmental officers at Calcutta and Bombay. The attempts to produce daily, weekly or monthly charts are, however, disappointing : there are no readings at all over a considerable portion of the map, and even where the pressure readings are most numerous their average errors are such as to make the resulting means in general untrustworthy for the investigation of seasonal variations. From time to time, however, the pressure departures may be large enough to be indicated with some reliability, and as the winds are correctly recorded it is proposed to plot the data of groups of seven days each on one chart and to examine for decidedly abnormal features, such as the northerly winds which have prevailed at times this year between Mauritius and the equator during the rains.

Investigation of the Upper Air.—*Kiteflying at Belgaum.* The work which Mr. Field started last year at Belgaum with the object of investigating the meteorological conditions of the upper air during the monsoon period by means of kites has been continued during the past year. The kites which had been previously used were repaired and strengthened, and several new kites of the pattern used by Dines in England were made in Simla. On the 11th of July the hut at Belgaum containing the oil engine and winding gear was opened and preparations made for flying the kites. For several days no rain fell and winds were only light, there being a break in the monsoon current which had not as yet set in with its normal intensity. On the 14th, 15th, and 16th the winds increased in strength and the conditions became favourable for kiteflying with

the result that heights varying between one and one and-a-half miles were reached each day : the weather could not however be regarded as thoroughly typical of the season.

The monsoon became reestablished on the 17th when rain fell and the wind increased considerably. During this day the highest kite ascent yet made in India was effected and good instrumental records were secured of the meteorological conditions up to a height of about twelve thousand feet above sea level. This flight although entirely successful was attended by considerable risk, for the wind became high and two of the four kites used having become unstable considerable difficulty was experienced in landing them unbroken. After this the monsoon set in with considerable vigour and the wind and weather conditions became such that kiteflying was impossible. It was not the average strength of the wind which caused the difficulties but the fact that the velocity varied irregularly from something like 20 miles an hour up to 60 miles or more, and throughout no single hour could moderate conditions be expected. The weather was dominated by rainstorms which moved rapidly across country in the direction of the wind, and each covered an area with a diameter of about two miles. A rain centre would appear on the horizon and pass over the kite station in about half an hour ; the wind in the front of this would rise to great violence and then die down to nearly a calm midway between this storm and the next, which would appear after a short interval. Naturally these storms proved fatal to the kites and as a consequence every attempt to obtain an ascent ended in failure. The kites were broken and mended until hardly a serviceable kite remained, and the whole of the time which could be given to this work passed without another successful ascent being made.

The results have been tabulated and are now being published. It may be remembered that in 1906 a dry layer was as a rule found at a height which varied from day to day between 2,500 and 8,300 feet above Belgaum, but conditions were only favourable for kiteflying at times when the weather was not thoroughly typical of the monsoon, and hence it cannot be inferred that the dry layer persisted when the rains were fully established. In 1907 this dry layer was once found at a height of about 5,000 feet, but not at any other time although heights considerably greater than those of 1906 were attained.

This experience has clearly shown that kiteflying during the monsoon

is much more difficult than had been anticipated and that methods peculiar to the circumstances must be developed. There is, however, no reason to expect that the difficulties will prove insuperable, nor that they should require a great expense of time or material in overcoming them.

Kiteflying over the Bay of Bengal and the Arabian Sea.—Shortly after returning from Belgaum Mr. Field proceeded to England on privilege leave : he had previously obtained permission to attempt to fly kites from the deck of the British India steamer on which he sailed from Calcutta on the 23rd of August. Four new kites having been rapidly made and a few of the old ones repaired before starting. Mr. Field was able to make four ascents in the Bay of Bengal and three in the Arabian Sea. The work was again full of difficulties, and one or two losses were sustained ; but it is expected that the records secured up to a height of 9,000 feet will give valuable information.

Balloons.—As mentioned in last year's report measurements are being made in Simla of the velocity and direction of the air currents in the upper atmosphere. In most civilized countries the implements used for exploring the atmosphere are 'ballons-sondes' or sounding balloons which are filled with hydrogen and carry to extremely great heights very light instruments that automatically record the meteorological conditions of the air as they pass through it. Such methods would have very great value in this country : for a knowledge of the temperature, humidity and direction of motion of the air would be of great value both to Indian meteorology and to meteorology as a general science. The conditions however make the use of recording instruments very difficult. A balloon sent up to reach very great heights would probably be carried hundreds of miles before reaching the ground again : and even if the place where it fell were sufficiently populous for it to be found it would not be likely to be returned owing to the ignorance and superstitions of the peasants. Under these conditions it appears wiser for the present to limit the work to the determination of the winds at different heights, and to ascertain the course and velocity from observations made with two theodolites at the ends of a measured base line, no attempt being made to recover the balloon. Readings of altitude and azimuth without the use of verniers are made alternately at intervals of twenty seconds, the theodolite being kept directed at the balloon by a second observer.

In November 1906 two ascents were made on the 9th and 22nd, the balloon being followed to heights of 29,000 and 34,000 feet respectively above sea level. On both these occasions the wind at the highest point reached was blowing almost exactly from the west, the divergence being not more than three degrees in either case. The velocity of the wind also was considerable, 54 miles an hour being reached at the highest point on the first date, and 80 miles an hour at the greater height on the second occasion. The next ascent effected on the 27th of February, showed almost exactly the same conditions as those prevailing on the 9th November. The height reached was 28,000 feet, the velocity was 49 miles an hour and the wind was exactly due west.

In March two more ascents were made and are interesting as showing how rapid changes may take place in an interval of a very few days. On the 4th a height of 32,000 feet was obtained and the wind was blowing there with a velocity of as much as 103 miles an hour. In direction also it was somewhat different from the usual west wind in that it was blowing from a point 19° to the south of west. Nine days later, on the 13th, the conditions had altered considerably : the balloon moved less quickly in a horizontal direction and was accordingly followed to a greater height than had previously been found possible. It was not lost until it had reached a height of 58,000 feet above sea level and its horizontal velocity, after rising to about 60 miles an hour, dwindled at the highest point to only 27 miles an hour. The direction of the wind also had undergone a change ; it was then blowing from a point 30° south of west, this being one of the greatest divergencies from a true west wind yet found at a great height above Simla.

The previous results show, as might be expected from what is known of the general air circulation, that the wind in the upper atmosphere over Simla has always a large westerly component ; but it is not so constant in either direction or velocity from day to day as might have been imagined.

Electrical Condition of the Atmosphere.—Although what is known of the electrical conditions of the atmosphere throws little light on the causes of the great meteorological changes, it seems very probable that some relationship must exist between the two classes of phenomena. The connexion between sunspots, magnetic storms and auroras shows that the sun's activity does affect the electrical and magnetic conditions of the earth's atmosphere, and with greater knowledge of the latter

some information as to the former may be expected. Broadly speaking the electrical condition of the atmosphere is defined by the state of ionisation of the air and by the electric potential gradient above the earth's surface. Last year apparatus was installed at both Calcutta and Simla for making determinations of these two factors, and in April 1907 a Benndorf self-registering electrometer was brought into use at Simla for automatically recording the variations in potential gradient. This instrument is now providing daily curves which will be discussed when a year's records have been obtained.

Apparatus for automatically and constantly recording the ionisation and conductivity of the air has been designed and is being made in the workshop of the Simla office. It is expected that this instrument will be in use before the end of the year; and the result derived from a comparison between its records and those of potential gradient should give valuable information.

Arrangements have also been made for measuring the quantity of electricity carried down by rain and other forms of precipitation. The insulated receptacle for the precipitation together with the mechanism for automatically recording its quantity and the quantity of electricity brought down with it have been placed in a hut which has been specially designed to protect the apparatus from the earth's field and from the effects of splashing. This instrument was completed at the end of the rains in Simla and there has been as yet no chance of obtaining any results.

Publications.—In addition to the Daily Weather Reports published at Simla, Calcutta, Bombay and Madras, the Monthly Weather Reviews, the Annual Summary, and various administrative pamphlets, the following memoirs have been published in the series of memoirs of the department:—

A discussion of the anemographic observations recorded at Rangoon from June 1878 to October 1901.

A discussion of the anemographic observations recorded at Chittagong from June 1879 to December 1896.

Both are by Sir J. Eliot, K.C.I.E., F.R.S., who is writing a series of memoirs on the winds of India.

The following memoirs are now in the press:—

A discussion of the anemographic observations recorded at Saugor Island from March 1880 to February 1904.

A discussion of the anemographic observations recorded at Alipore from March 1877 to February 1904.

A discussion of the anemographic observations recorded at Allahabad from September 1890 to August 1904.

A discussion of the anemographic observations recorded at Lucknow from June 1878 to October 1892. All four are by Sir J. Eliot, K.C.I.E., F.R.S.

Kite flights made at Belgaum during the premonsoon and monsoon periods in 1906. By J. H. Field, M.A., Imperial Meteorologist.

A meteorological atlas of the Indian Ocean north of latitude 12° S. has also been prepared, chiefly by Mr. Dallas, and is being published by Messrs. Bartholomew. The data of pressure and winds are based on logs collected in India from 1893 to 1904 and the atlas contains monthly normal charts of the pressure, winds, sea currents, and tracks of storms, together with charts of typical storms, and statements of the chief features contained in the charts.

TERRESTRIAL MAGNETISM

BY

GILBERT T. WALKER, M.A., ScD., F.R.S.,
Director-General of Observatories.

Magnetic Observatories.—*Bombay* (*Colaba and Alibag*). The tabulation and discussion of the series of magnetic observations at Colaba which extend over sixty years is approaching completion. Attempts also have been made to obtain satisfactory explanations of the discrepancies which appear in the past records owing to differences of site and of instrumental exposure. The observations are now made at Alibag, the electric tramways at Bombay rendering Colaba useless for the purpose: the autographic instruments at Alibag are of the Watson pattern and the old Kew pattern instruments will shortly be transferred thither.

Dehra Dun, Kodaikanal, Barrackpore and Toungoo.—Of these observatories, which have been established as base stations in connection with the magnetic survey, the first two were started in 1902, the third in 1903 and the last in 1904: they are all equipped with Watson

autographic instruments for declination, horizontal intensity and vertical force. The instruments for vertical force at Kodaikanal, Barrackpore and Toungoo were erected during the year under review, and after adjustment of the temperature compensation the following determinations of the temperature coefficients were made:—

Dehra Dun —5·2γ per 1° Fahr., Barrackpore +3·9γ, Toungoo —2·1γ and Kodaikanal +3·4γ. All these instruments have given good results except that at Kodaikanal where the magnet which had proved unsatisfactory at Dehra Dun has been temporarily mounted pending the installation of a new magnet in December next: it appears likely that the agate knife-edge of the present instrument is defective.

The temperature coefficient of the Toungoo horizontal force magnetograph which had previously given trouble owing to the system not having reached a steady state was satisfactorily determined, the value found being 7·4γ per 1° Fahr.

Earth inductors of the Schulze pattern have been installed in each observatory in place of dip circles, than which they are much more satisfactory. The mutual agreement of the new instruments is excellent, the greatest difference between two of them being 0·2′. One of the inductors has accordingly replaced dip circle No. 44 as the standard of the survey, and the difference of the indications is—

Inductor No. 30—Dip circle No. 44 = +0′·8.

The mean values of the magnetic elements at the observatories for 1906 are as follows:—

	Declination.	Horizontal Force.	Dip.
Bombay	1° 5·5′ E.	·36874	23° 7′·9
Dehra Dun	2° 39·2′ E.	·33365	43° 29′·8
Barrackpore	1° 14·1′ E.	·37259	30° 26′·4
Kodaikanal	0° 36·3′ W.	·37425	3° 21′·1
Toungoo	0° 43·6′ E.	·38715	22° 59′·2

Magnetic Survey.—The preliminary survey of India for which sanction has been given is planned to involve—

(*a*) Observations for declination, intensity and dip at about 1,100 stations, whose distance apart will be comparable with 35

or 40 miles, the "density" being one station to 1,300 square miles.

(*b*) Observations in successive years of the magnetic elements at 23 "repeat stations" in order to make possible the elimination of secular variation.

(*c*) Data from absolute and self-registering instruments at Bombay and the four special base stations already mentioned.

A beginning was made with field work in November 1901 and the operations up to the end of the year 1905-06 have been described in previous reports : by that time 958 stations had been occupied and 22 repeat stations established. During the past year field operations have been carried on by four detachments, two in Burma, one in Assam, Manipur and Lushai, and the fourth in Chota Nagpur, the Agency tracts of Vizagapatam and the tributary states of Orissa. In addition, observations were made at eight stations grouped round Buxar to investigate the abnormal value of declination found in 1903-04. The total number of new stations visited during the year was 152 and of stations occupied to date is 1,110 with 22 repeat stations. The field season commenced on the 19th October 1906 and the party proceeded to recess quarters on 1st May 1907.

The officer in charge of the Magnetic Party was Captain R. H. Thomas, R.E., and a second Imperial officer Lieutenant H. J. Couchman, R.E., was posted to the party in September 1906: with his assistance all the repeat stations, 22 in number, were visited. The officer in charge inspected the observatories at Dehra Dun, Barrackpore, Kodaikanal and Toungoo, and carried out comparative observations at each to determine the differences from the survey standard.

In addition the magnetic survey is indebted to Captain C. M. Browne, D.S.O., R.E., for observations of the magnetic declination at 25 stations on the Seistan trade route with equipment supplied by this party. Included in these observations is the largest value of east declination observed during the present survey, *viz.*, 5°E. at Malikshah in Lat. 29° 1′42″ Long. 62° 58′57″.

During the recess season the computations of the field work and the reduction and tabulation of the base station results for 1906 have been completed. The field instruments were all compared with the survey

standards at the beginning and end of the field season. Further investigations have been made with regard to the correction of the field observations for diurnal variation. From the results from the four base stations, Colaba, Dehra Dun, Barrackpore and Kodaikanal, simple formulæ connecting change in diurnal variation with change in latitude had already been established, by which using the results of two base stations the diurnal variation at any third station may be determined: in the present investigation the results of Toungoo observatory were included to determine whether the formulæ would still hold good within the wider limits of longitude. The results were quite satisfactory, and the formulæ have now been established for the limits of the Magnetic Survey of India.

It was again noticed that the results when using the Kodaikanal H. F. values were never so satisfactory as when this observatory was excluded from the discussion: in the reduction therefore this observatory will not be used, if the curves from two other base stations are available. The discordance is probably connected with the fact that this observatory is situated on rock which is distinctly magnetic.

Investigations into the variation of disturbances from point to point are in progress at the present time on lines suggested by Sir A. Rucker. The investigations, which require a knowledge of the variations of the vertical component of the earth's field, could not be commenced until results from the V. F. magnetographs were available, and the installation of these instruments was completed only in March last.

During the next field season, the last of the preliminary survey, three detachments will be employed in Burma and its administered tracts while a fourth will observe in India in such tracts as remain. It is estimated that 110 new stations will be established, which with previous work will give a total of 1,220. The extension of the survey into the Himalayas, which is most desirable, must be deferred until the detailed survey is begun.

It is hoped that the reduction of the field work may be so far advanced as to indicate before the field season 1908-09 the disturbed districts in which detailed observations should be taken: but this reduction cannot be properly effected until satisfactory formulæ, empirical or theoretical, have been found for the variation from point to point of disturbances, and sufficient data have been accumulated for the investigation of the proper values to assign to the secular change

in the districts intervening between the base stations: should then, as is probable, this reduction not be sufficiently advanced, the detailed survey may be begun by the examination of the northern edge of the Deccan trap which has already been asked for by the Geological Survey.

GEODESY

BY

J. ECCLES, M.A.,
Officiating Superintendent, Trigonometrical Surveys.

Trigonometrical Operations.

Principal Triangulation.—During the year under report the Principal Triangulation was extended in Baluchistan westwards from Longitude 64½°E. up to Longitude 62½°E. keeping along the parallel of 29° North.

The country in which the work lay is about as desolate and barren as any land could be and is practically uninhabited except for a few nomad shepherds and the inmates of the levy posts maintained along the Seistan Trade Route. It is, however, full of interest to the geologist and the surveyor.

Up to Longitude 63°E. the triangulation was carried on by quadrilaterals and a tetragon, but west of this the country presented considerable difficulty to the extension of the work, on account of the enormous sandy and stony plains which stretch as far as the eye can reach to the north and south of Koh-i-Sultan (an extinct volcano which lies about Latitude 29°10′N., Longitude 62°50′F).

Here a hexagon was employed with its central station on the highest point of Sultan (Miri) and the other stations on low hills except at Kondi, where the station was in the open plain.

Abnormal conditions of terrestrial refraction were met with and distinct evidence of earth tremors noted.

Observations to the plain station, Kondi, from the other stations were accomplished without any great difficulty; but when it came to observing from it, the most peculiar effects of refraction and its consequent mirage were noticed.

The ray Kondi-Tuzgi was about 20 miles in length, but a heliotrope, although cut down to 3″ in diameter, in the middle of the day appeared

an enormous luminous disk subtending 4 minutes of arc with a "reflection" of equal size in the "water of the mirage": from this a luminous streak appeared to stretch to within a mile or so of the observer. The above figures give the heliotrope an apparent diameter of 120 feet, the real one being 3 inches.

Two heliotropes were often seen side by side and on one occasion three were visible.

To obviate the effects of this abnormal state of things, observations were made under as greatly differing conditions as possible and at different times of the day and night.

While the observations were proceeding in the plains great difficulty was being experienced in building a station on the summit Koh-i-Sultan: all the local stone split when wetted owing no doubt to the presence of unslaked lime and it was necessary to bring stone from a distance. Twice after completion the station was seriously cracked by earth tremors: such tremors occurred on several occasions during observation, causing a visible quivering of the instrument; they did not last long but occurred at any time of the day or night and had nothing to do with the atmospheric conditions.

At all the last stations the active volcano, Koh-i-Taftan, which is in Persian territory, was observed. When near it, large volumes of smoke were visible through the telescope constantly rising and spreading over its snow-capped peaks, one of which exceeds 13,000 feet in height.

There is a local tradition that Koh-i-Sultan was active within comparatively recent times and this is distinctly borne out by the appearance of the mountain. These remarks are of greater interest from the fact that in most books on volcanoes the highly volcanic region between Koh-i-Taftan and Koh-i-Sultan with its many distinct craters is either not mentioned at all or is dismissed with the barest of notes.

Observations for magnetic declination were taken at several stations east of Nushki: strong local attraction was found to exist at one or two places, but on the whole the declinations were in conformity with those already determined in Eastern Baluchistan and Sind. The length of the series was 150 miles and the triangular error deduced from 15 triangles was 0·41″.

In Dehra Dun observations were taken at three stations of the Great Arc Series, Banog, the east and the west ends of the Dehra Dun Base and at one new station, Top Tiba, to see if any movement had

been caused by the earthquake of 1905. No movement was detected among these stations, but before it can be definitely stated that no movement has taken place, it will be necessary to continue the revision into the plains.

During the present field season the triangulation will be continued to the Persian border and a meridional Series will be commenced to connect the Kalat Series with the Mekran series. Another Series will be commenced starting near Kalat running in a north-easterly direction which will finally be joined on to the Great Indus Series. The Salween Series will be continued southwards to Latitude 22°, where it will bend eastwards towards Siam.

2. Himalayan Heights.—Observations of Himalayan heights in order to try and obtain some definite information on the difficult question of refraction were carried out during the year at four stations—Mussoorie, Nojli, Nag Tiba and Dehra.

At Mussoorie the heights of snow peaks, and of the two stations on the plains at Nojli, were lower in the spring of 1907 than in the autumn of 1906, the difference in the height of Bandarpunch being 11 feet, of Srikanta 8 feet, of Jaonli 5 feet, of Kedarnath 12 feet, of Nojli Tower Station about 12 feet and of Nojli ground level station about 9 feet. Similar differences were found in the preceding year.

It follows that in the past two years refraction has been greater in the autumn than in the spring.

The difference in the heights of snow peaks between the autumn of 1905 and the autumn of 1906, and between the spring of 1906 and the spring of 1907, were, respectively, as follows:—

Name of snow peak.	Autumn, 1905—06.	Spring, 1906—07.
	Feet.	Feet.
Bandarpunch . .	+ 7	0
Srikanta . . .	+ 5	− 13
Jaonli	+ 8	−10
Kedarnath . . .	+16	No observations in spring, 1906.

During 1906-07, it sometimes happened that the angles of depression to the two stations at Nojli were less at 10 A.M. than at 8 A.M. by amounts varying from 2 seconds to 10 seconds; thus the heights of these two stations appeared from 2 feet to 10 feet higher at 10 A.M. than at 8 A.M. This is contrary to the common idea that refraction is greatest about 8 A.M.

At Nojli, the changes in the angle of elevation of Mussoorie at the time of minimum refraction have been very small during the years 1905-06 and 1906-07.

Owing to insufficient observations no statement can be made as to the seasonal changes in the heights of the snow peaks as seen from this station.

At Nag Tiba, the heights of snow peaks in the spring of 1907 were greater than in the spring of 1906, Bandarpunch being 8 feet, Srikanta 14 feet, and Jaonli 18 feet, higher.

There has been no change in the apparent difference of height between Mussoorie and Dehra or between Mussoorie and Nag Tiba during the years 1905-06 and 1906-07.

3. Base Line Apparatus.—As stated in last report Captain Turner, R.E., was deputed to study the whole question of the measurement of base-lines by means of Invar Wires. He visited the International Bureau of Weights and Measures at Sévres where he was treated with the greatest courtesy. His report has been published in pamphlet form. While he was at Sévres and afterwards he made strong representations in favour of a new metric standard instead of the present 10-foot Bar A. A radical change like this required careful consideration, but when Colonel Burrard wrote and said that Dr. Gill threw doubt on the accuracy of the comparison of Bar A, it was felt that a new standard would probably be necessary, the only question being whether the unit should be the foot or the metre. The foot is not a proper standard of length, since it is merely part of the length of a certain piece of metal under certain conditions, at a certain epoch, and is certainly liable to alter as time goes on. On the other hand, the metre derives its length from a certain physical quantity, namely, the wave-length of a certain line in the spectrum of cadmium, which can be reproduced. A metre is in fact equal to " 1,553,164 times the wave-length of the red line of the spectrum of cadmium when the latter is observed in dry air at the temperature of 15°C. of the normal hydrogen-scale at a pressure of 760 m. m. of mercury at 0° C."

A further communication was shortly afterwards received from Colonel Burrard in which he said that he had interviewed Professor Darwin and Professor Baklund, the celebrated Russian Geodesist, and, that both of these scientists were strongly in favour of the change to the metre being made in the Indian standard. Professor Baklund stated that the identical question had to be faced at Pulkowa and that they accepted the metre without hesitation.

Professor Darwin recommended that the 10-feet Bar A should be carefully compared in India against the secondary standard 10-feet Bars I_B and I_s and that it should then be sent to Sévres to have its length determined by Dr. Guillaume in metres, after which it should be sent to the National Physical Laboratory for evaluation in English feet, a second comparison being made with bars I_B and I_s after Bar A's return to India.

In accordance with this, it has been arranged to have Bar A compared very carefully with Bars I_B and I_s. The former will then be carefully packed and forwarded to Sévres through the India Office while the secondary bars will be carefully stored away to await the return of Bar A.

When such geodesists as Dr. Gill, Professor Darwin and Professor Baklund express such decided opinions in favour of the metre, there does not seem to be any other course open to the Indian Government than to adopt it for base-line operations. The unit employed in topographical work will still be the foot.

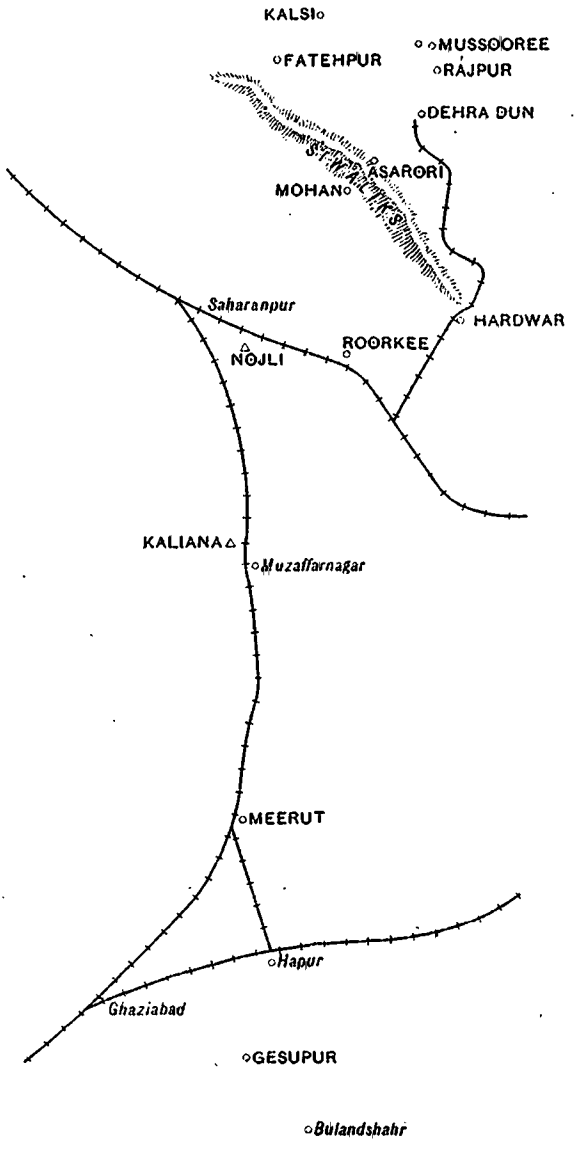
The wires necessary for field measurements will cost the same whatever the unit and the only extra expense in the field apparatus will be the cost of a 3 or 4 metre Invar bar for use in the field. Another 3 or 4 metre bar composed of whatever alloy of nickel and steel is now considered by specialists to be the most permanent will be required as the fundamental standard.

As soon as the apparatus arrives in India every endeavour must be made to measure whatever base-lines are necessary at once, as the triangulation, good as it is, has got too far away from the present base-lines to satisfy the views at present held in geodetic science.

Gravimetric Survey.

1. Pendulum Operations.—The programme of the year 1906-07 was framed so as to throw further light on the variation of gravity in the

SKETCH MAP SHOWING PENDULUM STATIONS OF 1906-07.



Pendulum Stations shown thus.....ROORKEE

neighbourhood of the Himalayas and the Siwaliks. The stations selected were—

1. At foot of Himalayas . .	Rajpur.
	Kalsi.
2. In the Dun	Dehra (already observed at).
	Fatehpur.
3. In or near the Siwaliks . .	Asarori.
	Mohan.
	Hardwar.
4. Outside the Siwaliks, but not far from them.	Roorkee.
	Nojli.
5. Stations on or near the Great Arc extending southwards from Nojli.	Kaliana.
	Meerut.
	Gesupur.

The results of the season's work were satisfactory. The temperature of the pendulums seems to be more correctly given by the thermometer fitted into the dummy pendulum, than it was by those which were attached to the stand; moreover, at all the stations visited, fairly good observing rooms were obtained.

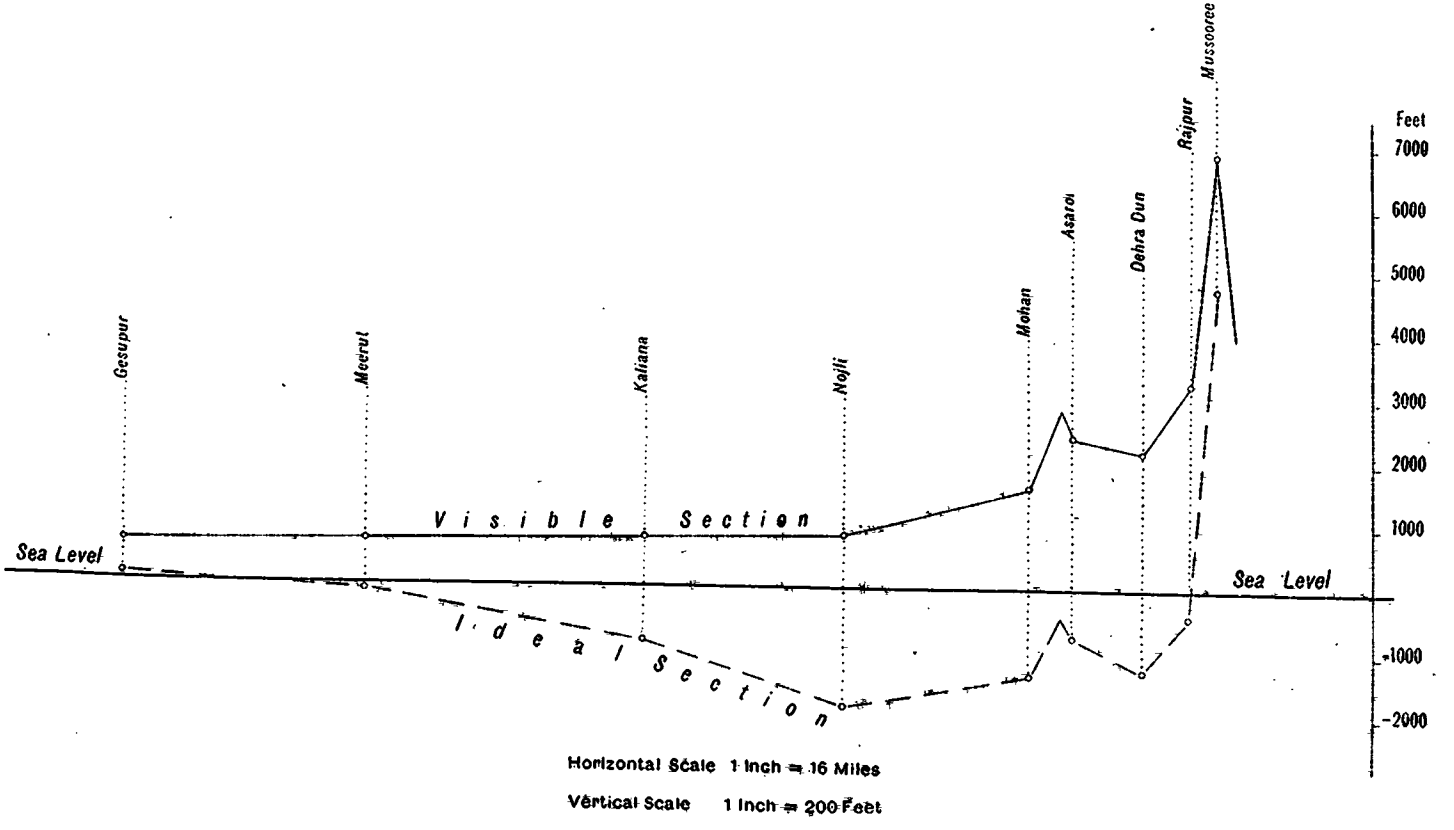
The differences between the observed values of g and the calculated values are shown in the following table which is of the same form as that given in last year's report (page 63):—

The attached sketch map shows the position of the stations.

—		Excess or deficiency of observed force of gravity.	Visible excess of rock above sea-level height of station = H.	Invisible excess or deficiency of rock as revealed by the pendulum = D.	Resultant excess or deficiency of rock, *i.e.*, height of station above sea-level if crust were reduced to normal density H, + D.
Station	Region.	c. m.	Feet.	Feet.	Feet.
Rajpur	Foot of Himalayas.	—0·130	3,321	—3,700	—380
Kalsi	Foot of Himalayas.	—0·105	1,684	—2,980	—1,296
Dehra	In the Dun	—0·123	2,240	—3,500	—1,260
Fatehpur	In the Dun	—0·100	1,415	—2,840	—1,425
Asarori	In the Siwaliks	—0·112	2,467	—3,180	—713
Mohan	In the Siwaliks	—0·105	1,660	—2,980	—1,320
Hardwar	In the Siwaliks	—0·114	949	—3,240	—2,290
Roorkee	Outside the Siwaliks.	—0·107	868	—3,040	—2,172
Nojli	Outside the Siwaliks.	—0·096	879	—2,730	—1,851
Kaliana	26 miles south of Nojli.	—0·058	810	—1,650	—840
Meerut	62 miles south of Nojli.	—0·027	734	—770	—36
Gesupur	92 miles south of Nojli.	—0·020	691	—570	+121

The defects in the force of gravity are somewhat greater at Dehra Dun and Rajpur than at the similarly situated stations of Fatehpur and Kasli in the western Dun, but on the other hand the height of the two latter stations above sea-level is considerably less than that of the two former, and if we imagine the crust reduced to normal density, the depth below sea-level in the western Dun will be greater than at Dehra, though not so great as at Hardwar, Roorkee, and Nojli.

VISIBLE AND IDEAL SECTIONS FROM GESUPUR TO MUSSOOREE



The accompanying diagram is a section through Gesupur, Meerut, Kaliana, Nojli, Mohan, Asarori, Dehra Dun, Rajpur, and Mussoor showing the actual profile of the ground and the profile when the crust is reduced to normal density.

On the meridian of Darjeeling and also on the line across the Punjab, stations were found at which the force of gravity was in excess of the normal value. At the most southerly of this year's station, Gesupur, the force was still in defect and it is probable that greater values will be found when the line is extended.

One of the most important objects to be borne in mind in designing future programmes is the locating of the exact position of the line, roughly parallel to the Himalayas, where the excess of gravity is a maximum. The existence of such a line is shewn by the latitude observations, but it cannot be satisfactorily located except by the pendulum.

Since the last report was written the results of the observations which Dr. Heckor made in conjunction with Major Lenox-Conyngham at Jalpaiguri in 1905 have been received.

He finds by direct comparison with Potsdam the value of the acceleration due to gravity at Jalpaiguri to be 979·624 c.m.

Major Lenox-Conyngham's result which is also based on the Potsdam value of g. through Kew and Dehra Dun is 979·622 c. m. The difference between the two is within the error of observation.

The accordance is highly satisfactory and gives confidence in the accuracy of the work so far accomplished.

During the coming year observations will be taken in the south of India at stations situated in different types of regions, such as the Mysore Plateau, the East and West Coasts, the Nilgiris, Pulneys, and Shevaroys, and in the Central plain. This part of India is geologically very different from the parts that have hitherto been visited and it will be of great interest to ascertain whether the characteristics which have been found both in the Himalayas and in the Suleiman Mountains are present in the Southern hills also.

Deflection of the Plumb-line.—During the season 1906-07, observations to determine the deflection of the plumb-line were taken at eleven stations in the Kathiawar Peninsula and round the Gulf of Cambay, distributed as follows:—

Three stations on the Kathiawar Meridional Series.

One station on the Kathiawar Minor Longitudinal.
Two stations ,, Gujerat Longitudinal.
Five ,, ,, Singi Meridional Series.

In addition observations were taken at Dehra Dun for the purpose of ascertaining whether the earthquake of 1905 had created any disturbance in the distribution of local masses of such a nature as to cause to change in the value of the deflection of the plumb-line.

Troughton and Simms' Zenith Telescope No. 1 was used for taking the Talcott observations. At each station from 20 to 40 pairs of stars were observed.

The following table gives the results of the season's work :—

Name of station.	Latitude.	Longitude.	Height above M. S. L.	Deflection of the Plumb-line.
			Feet.	"
Dangarwadi. H. S. . .	20°43′	70°59′	96	8·52
Kunkavav. T. S. . .	21°39′	70°59′	591	1·65
Dungarpur. H. S. . . .	22°48′	71°2′	404	4·69
Chamardi. H. S. . . .	21°49′	71°58	42	2·77
Ingrodi. T. S. . . .	22°57′	71°51′	118	5·08
Paldi. H. S.	22 54′	72°34′	208	5·47
Ghorarao. H. S. . . .	22°52′	73°24′	323	3·12
Pavagad. H. S. . . .	22°28′	73°33′	2,721	4·38
Sidhpur. H. S. . . .	22° 4′	73°31′	169	3·44
Alamvadi. H. S. . . .	21°35′	73°33′	848	3·68
Tarbhan. H. S. . . .	21° 1′	73°6′	140	5·77

These results shew the prolongation still further to the south-west of the belt of the negative values of O-C, which runs south-west and north-east with the tract of maximum values approximate along the line Deesa-Agra. There are indications, besides, that to the south-west of Deesa the value of the northerly deflections is somewhat smaller than it is to the north-east. It also appears that over the southern portion of

the Kathiawar peninsula relatively large northern deflections may be expected; that over a central belt small northerly values will occur, which increase to the north.

The fact that the most southerly station, Dangarvadi, exhibits a greater northerly deflection than that of the northern station, Dungarpur, shows that the plumb-lines in the south and north of the peninsula are relatively inclined towards each other and this considered in conjunction with the result determined at the intermediate station, Kunkavav, which is smaller than either northern or southern value, indicates that there is a source of attraction within the peninsula itself.

If there are three stations approximately on the same meridian and one source of attraction lying either north or south of all three stations, the value of the deflection at the middle station will lie somewhere between those at the north and south stations. This is true for every source of attraction situated in a latitude either less than that of the southern station or greater than that of the northern. It is consequently true for any combination of such attractions. That is, in every case of a group of sources of attraction none of which lie in latitudes intermediate between those of the southern and northern stations, the value of the deflection at the middle station will be somewhat between those of the other two. To produce a deflection at the middle station not of this nature but greater or less than the other two, there must be a source of attraction lying between the latitudes of the north and south stations. The results in the table above give an instance of this. The deflection at Kunkavav is $-\cdot1\cdot65''$ less than either of the values at Dangarvadi and Dungarpur, $-8\cdot52''$ and $-4\cdot69''$ respectively, showing that a source of attraction is to be looked for within the peninsula itself. The result found at Chamardi points to the same conclusion.

Considering only these three values, $-8\cdot52''$ at Dangarvadi, $-1\cdot65''$ at Kunkavav, and $-4\cdot69''$ at Dungarpur and assuming that these deflections are due to a mass of relatively great density concentrated at a point somewhere in the line Dangarvadi-Dungarpur, it can be shewn that if this point is situated anywhere between the surface and 5 miles below, its distance north of Dangarvadi would be about 50 miles. Much weight, however, cannot be given to any such result based on the above stated assumption, for in nearly all cases the ratio between the volume occupied by the mass and its distance from the station of observation is such as to render unsound the assumption that the mass

is concentrated at a point and consequently the law of inverse squares will not be applicable.

The general character of the Kathiawar deflections is what one is led to expect by a glance at the geology of the peninsula. The central portion is covered with basalt. Dangarvadi and Dungarpur are respectively close to the southern and northern edges, while Kunkavav is roughly over the centre of the basalt overflow. This being so, it was to be expected that the plumb-lines at the two former stations would be inclined inwards and from what has been said above that the value at Kunkavav would lie outside the range of the values at the other two stations.

At Thikri Latitude 22·2′ Longitude 765·37′ a deflection of +0·84″ had been found, the stations to the north and south of Thikri giving negative values. At Ghorarao, Pavagad, and Sidhpur were also found northerly deflections.

Thus at Thikri in the Nerbudda valley there is a small area of abnormal positive deflections.

The observations at Dehra Dun show that no change has taken place.

Tidal Operations.

During the past year tidal registrations by self-registering tide-gauges, were taken at the ports of Aden, Karachi, Bombay (Apollo Bandar), Bombay (Prince's Dock), Madras, Kidderpore, Rangoon, and Port Blair.

It was hoped that the tidal observatory at Moulmein would be ready early in the year, but various delays have occurred and the work on the observatory has not yet been commenced.

Nothing further has been done with regard to the proposed tidal observatory in the neighbourhood of Suakin.

The scheme proposed for the establishment of tidal observations at Kuweit and Bahrein in the Persian Gulf is now under the consideration of the Secretary of State for India, who is awaiting the results of experiments which are being made by the Admiralty with regard to a new pattern tide-gauge which is said to be better and cheaper than the pattern now in use.

A tidal wave caused by volcanic disturbance in the Bay of Bengal on 4th January 1907 was felt at Port Blair, Madras, Bombay, and

Karachi, but not at Aden or at any of the riverain stations. At Port Blair the tidal wave was more conspicuous than at any of the other Indian tidal stations where tide-gauges are at work. The first disturbance appeared to have commenced at 1-45 P.M. on 4th January 1907, the oscillations of the pencil due to the tidal wave were slight up to 2-40 P.M., after which they increased in frequency and in height up to 6-30 P.M., the time of slack water at low tide, when the wave was greatest, the height being 5 inches. After this the curve showed a diminishing of the wave until it ceased at 10-20 P.M. on 6th instant. The oscillations were most marked at each slack water at low and high tides.

Oscillations due to the tidal wave are traceable on the tidal diagram at Madras between midnight of 4th January and midnight of 5th. They are insignificant.

The effect of the tidal wave at Bombay is noticeable between 7 P.M. on 4th and 9 P.M. on 5th January, the oscillations of the pencil occurring only at or about the time of slack water at low and high tides. The greatest movement of the pencil out of the normal was 2 inches at 2-50 A.M. on 5th.

At Karachi the disturbance commenced at 5 P.M. on 4th about the time of slack water at low tide; and lasted till 10 A.M. on 6th January 1907. It was distinctly noticeable between 11 P.M. on 4th and 9 P.M. on 5th; at 1-15 A.M. at slack water at high tide on the 5th, the pencil showed an abnormal movement of the wave of 3 inches.

It was reported by the Director, Royal Alfred Observatory, Mauritius, that a tidal wave occurred at Mauritius, Rodrigues, and Reunion on the afternoon of the 4th January 1907.

The Director-General of Observatories in India reported that the Simla Seismograph recorded a large distant earthquake on the 4th January at 10-55 A.M. The distance of its centre from Simla was computed to be about 2,400 miles.

The tidal observatory at Karachi was wrecked on 6th June last by a cyclone which swept the cabin and tidal and meteorological instruments bodily into the sea. This occurred about 10-30 A.M.

The high water morning tide rose to 5 feet 3 inches higher than the predicted height for that tide, the actual being 12 feet 8 inches and the prediction 7 feet 5 inches.

The force of the wind was greatest between the hours of 9 A.M. and noon, the velocity being 85 miles per hour. The rainfall reported was

1·3 inches. The occurrence being reported, instructions were immediately sent to the Port Engineer to have tide-pole readings taken and to start the re-erection of the cabin. The work is almost complete and another set of instruments will be started at once.

The tide-gauge has been at work since 1881 and for the past 26 years gave a continuous and excellent record.

Owing to the contemplated enlargement of the Madras Harbour, the Port Engineer has stated that in all probability it will be necessary to remove the Tidal Observatory from its present position to some point on the new arm of the harbour which will project northwards.

Levelling Operations.

Levelling operations were carried out in the Punjab, United Provinces, Bombay Presidency, and Madras Presidency.

The total levelling executed amounted to 805 miles, of which 289 miles was new levelling and 516 miles revision work. The Bench-marks connected were 18 Standard, 70 embedded, 677 inscribed and 46 others such as railway, irrigation, etc.; 16 Trigonometrical Stations were also connected.

On the line Bombay to Kosgi, 8 embedded and 141 inscribed Bench-marks have been lost or destroyed, out of a total of 461. This is owing to the extension of railway stations and platforms, the renewal of bridges and culverts, duplication of railway line, etc. At Ahmednagar, when connecting the Standard Bench-mark there, 14 old Bench-marks could not be found; the bridge copings all along the railway were either being renewed or re-cobbled and many Bench-marks were found to have been destroyed by this means.

The revision of the level line, Bombay to Madras, was during the past season, carried as far as Kosgi, a station on the Madras Railway, distant 472 miles from Bombay.

The table below shows the discrepancies between the levelling of 1877-81 and 1906-07.

The mean sea level at Bombay derived from tidal observations taken in 1876-77 is 10·141 feet above the present zero of the gauge. The observed heights of 1877-81 are reduced to this datum.

The mean sea-level at Bombay deduced from tidal observation taken between 1878 and 1904 is 10·236 above the zero of the gauge. The observed heights of 1906-07 have been reduced by the levellers to

this datum. In order to make the observed values obtained in 1877-81 comparable with those of 1906-07.

A common datum line is required, which in the following table is the mean sea level of 1876-77. The difference ·095 has therefore, with its proper sign, been applied to the heights of 1906-07 :—

Approximate distance in miles from Bombay.	Name of Bench-mark.	Observed Heights above Mean Sea Level 1876-77, in feet.		Difference with sign for new value against old.	Heights published in Pamphlet, in feet.	Remarks.
		Seasons 1877-81.	Season 1906-07.			
0	G. T. S. At Town Hall, B. M. Bombay.	19·859	19·843	—·016	19·80	
2	G. T. S. At Prince's Dock. B. M.	10·855	10·815	—·040	10·70	
33	G. T. S. At Kalyan Railway Station. B. M.	25·270	25·242	—·028	24·91	
71	G. T. S. At Kampoli Railway Station. B. M.	232·240	232·312	+·072	231·73	This is over the Bor Ghat.
77	G. T. S. At Khandala Railway Station. B. M.	1790·885	1790·754	—·131	1790·36	
152	G. T. S. At Kedgaun Railway Station. B. M.	1776·889	1776·773	—·116	1776·18	
165	G. T. S. At Dhond Railway Station. B. M.	1693·296	1693·108	—·188	1692·41	

Approximate distance in miles from Bombay.	Name of Bench-mark.	Observed Heights above Mean Sea Level 1876-77, in feet.		Difference with sign for new value against old.	Heights published in Pamphlet, in feet.	Remarks.
		Seasons 1877-81.	Season 1906-07.			
183	G. T. S. At Diksal □ Railway B. M. Station.	1658·706	1658·507	—·199	1657·72	
236	G. T. S. At Barsi-road □ Railway B. M. Station.	1678·540	1678·066	—·474	1677·38	
286	G. T. S. At Sholapur □ Railway B. M. Station.	1493·351	1492·526	—·825	1492·07	
357	G. T. S. At Gulbarga ○ Railway B. M. Station.	1490·924	1489·987	—·937	1489·50	
441	G. T. S. At Bridge near Raichur ○ Railway B. M. Station.	1288·655	1286·786	—1·869	1286·78	
472	G. T. S. At Kosgi □ Railway B. M. Station.	1239·957	1238·016	—1·941	1238·10	

The differences between the old and new levelling throughout the line from Bombay to Kosgi, are cumulative; no large individual error has been disclosed; on the section Gulbarga to Raichur, which shows the greatest discrepancy, the error is likewise of a cumulative nature.

The most probable source of error is taking long range shots at a time of day when the air is boiling and the radiation excessive. This source of error has been especially guarded against in the observations taken within the past few years.

The line Gulbarga to Raichur levelled in 1879-80, was done towards the close of the field season and traversed country which is undulating for the first 30 miles and flat and sandy for the rest of the length. It is possible that radiation was at times excessive whilst observations were being taken.

The average discrepancy per mile between Bombay and Raichur is 0·004 foot.

That between Gulbarga and Raichur 0·011 foot.

The closing discrepancy between the mean sea-level at Bombay and the mean sea level at Karwar, using the earliest values, was 0·93 foot, Karwar being higher than Bombay. The levelling route was Bombay, Kedgaon, Hubli, Karwar.

The closing error now obtained by the same route is 0·814 for Karwar, using the new value for Kedgaon.

By the line Bombay, Kedgaon, Gulbarga, Raichur, Bellary, Hubli, Karwar, the error now computed is 0·175 at Karwar, introducing the new value for Raichur.

This would seem to indicate a large error on the line Kedgaon to Hubli.

Levelling to Mussoorie was first done in April-May 1904.

Owing to the earthquake on 4th April 1905, the line was revised in April-May of this year.

The difference obtained at the terminal point, which is a Bench-mark at "Dunseverick," Vincent's Hill, was 0·468 foot, or 5½ inches, the height determined in 1905 being lower than in 1904, showing apparent sinking of Mussoorie. As a portion of the line, Kolukhet to Mussoorie, was executed by single levelling, in May 1905, the difference in height obtained could not be finally accepted and it was therefore decided to revise this portion by double-levelling. This was done in October of the same year.

The general result showed an apparent sinking of Mussoorie of 5 inches instead of 5½ inches.

With the object of testing this conclusion, the section Saharanpur to Dehra Dun was relevelled in April-May 1907, the levels starting from the embedded Bench-mark at Saharanpur and closing on a mark at the Dehra Survey Office, the identical mark from which the levels to Mussoorie emanated.

Assuming the old Bench-mark at Saharanpur to be unchanged, the results of the present levelling seem to indicate that a gradual upheaval took place towards the Siwaliks. This is first noticeable at the embedded Bench-mark at Mohan (27 miles from Saharanpur). Unfortunately two old Bench-marks at Kailaspur and Bhatpura, 6 and 16 miles respectively, from Saharanpur, could not be found.

The following figures show the difference in height of Bench-marks along the line between the old and new levelling, the values of 1906 being higher than the old values:—

Saharanpur	0·000 foot
Mohan 27 miles from Saharanpur southern side of the Siwaliks	+0·330 „
Mohabawala 37 miles from Saharanpur northern side of the Siwaliks	+0·365 „
E. end Dehra 38 miles from Saharanpur Base Line	+0·394 „
Dehra Survey Office 44 miles from Saharanpur .	+0·444 „

The difference found after the earthquake in the height of Mussoorie, accepting Dehra as correct, was —0·418 foot. By accepting Saharanpur as unchanged, we now find that Dehra appears to have risen by an almost equal amount.

Combining the results, if Dehra is said to be unchanged then Mussoorie and Saharanpur have both sunk by 5 inches; if Saharanpur has not been disturbed then Mussoorie may be said to remain unaltered and Dehra raised by 5 inches.

Attached is a diagram showing apparent vertical displacements between Saharanpur and Mussoorie.

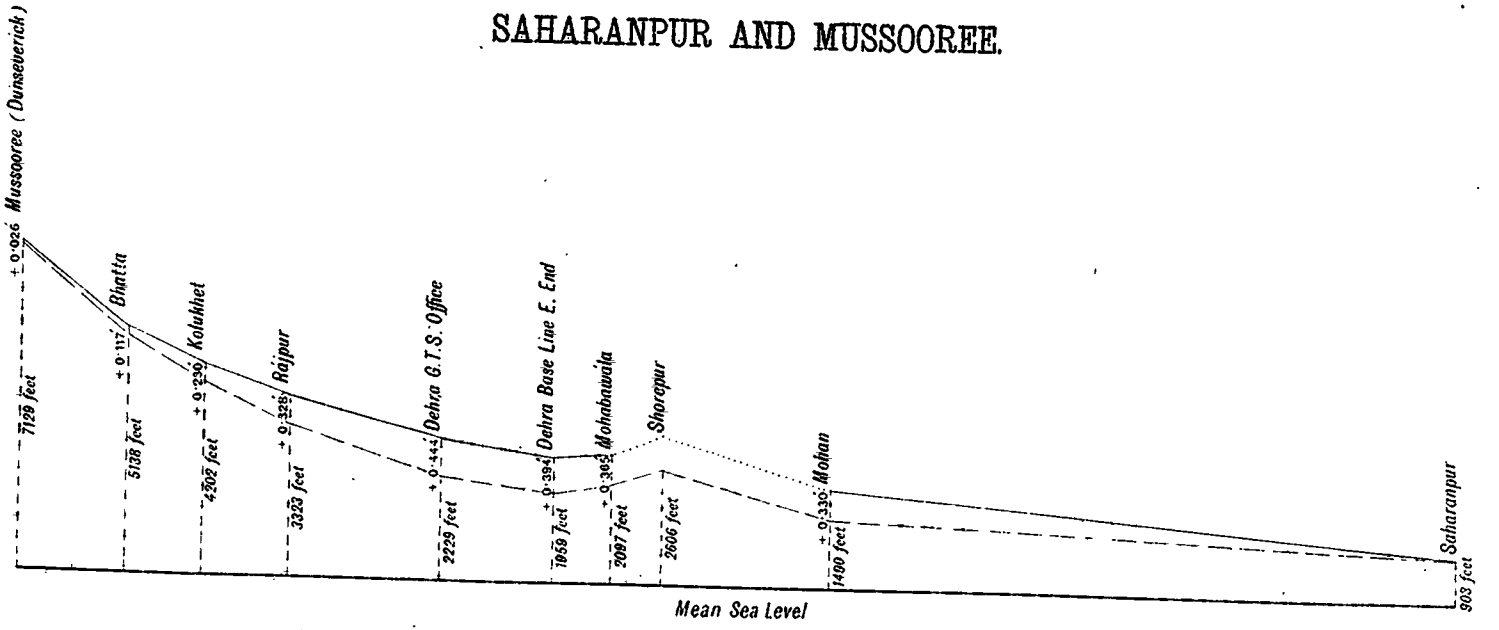
In the course of levelling operations in the Punjab, the Indus River was crossed by 3 distinct methods of levelling, these being (1) by means of the old tide-pole or water-gauge method. (2) By vertical angles. (3) By actual levelling of precision.

The place where the river was crossed was between Darya Khan and Dera Ismail Khan.

The time of year was late in December, when the width of the main channel was at its narrowest, being about ½ mile.

The direct levelling was rendered possible by the fact that three or four little sand islands existed in the stream some distance below the place where the tide-poles were erected.

DIAGRAM SHOWING VERTICAL DISPLACEMENT BETWEEN SAHARANPUR AND MUSSOOREE.



NOTES.

The Shoreper S.M. not having been found, a direct comparison with the top of the "Siwaliks" could not be made, hence shown in diagram by dotted lines.

Old line of Levels shown in bars. — — —

Horizontal Scale 1 Inch = 4 Miles

Vertical Scale 1 Inch = 200 Feet

Vertical Displacement 1 Inch = 1 Foot (shown thus + 0·330)

The values of difference of height obtained by the three methods are shown in the table below:—

By Tide-pole method.	By Vertical angles.	By actual levelling.
From forenoon observations. 1·201 feet	From forward angles . 0·938 foot	By First Leveller . 0·930 foot
From afternoon observations. 1·192 „	From back angles . 0·900 „	By Second Leveller . 0·922 „
Mean 1·197 feet	Mean 0·919 foot	Mean 0·926 foot

In December 1900 similar experiments were made on the Ganges River at Damukdia.

The distance across the river between the referring marks was 1·28 miles.

The result of the operations was that the difference of heights between the referring Bench-marks was found to be:—

By vertical angles 2·139 feet
By levelling 2·132 „
By water gauges 2·212 „

In 1856 the River Chenab was crossed by two methods (1) by means of tide-poles, (2) by direct levelling. The difference was ·048 of a foot, the breadth of river being 12 chains.

The difference between results by tide-pole method and by levelling is thus:—

On the Chenab (1856) ·048 of a foot.
„ „ Ganges (1900) ·080 „ „
„ „ Indus (1906) ·271 „ „

while the difference between the results by levelling and by vertical angles is—

On the Ganges +·007 of a foot.
„ „ Indus —·007 „ „

The above figures would seem to establish the superiority of the vertical angle method over the tide-pole method.

An American pattern level, known as the "Binocular Precise Level," constructed after the design in use in the United States Coast, and

Geodetic Survey, manufactured and supplied to this Department by George N. Sægmullar, Washington, United States, America, has for the first time been used by Indian Survey levellers during the past field season. The levellers found them to be light and handy little instruments and to fully bear out their reputation for accuracy and the attainment of speed in levelling.

Their employment involved certain alterations in Indian methods, the procedure adopted being a combination of the American and Indian systems.

Up to date the number of Standard Bench-marks completed is 41 ; of these 36 have been connected, 5 remain to be levelled to. The number under construction is 27. In all 68 have been dealt with. Arrangements are being made to continue the erection of Standard Bench-marks during the coming year.

GEOGRAPHY

BY

J. ECCLES, M.A.,

Officiating Superintendent, Trigonometrical Surveys.

In April 1906 Dr. Stein left India for Khotan to continue his archæological researches. He took with him a surveyor belonging to the Survey of India and has from time to time sent back traces of the topographical work done. The surveyor is returning owing to ill-health and another has been sent to assist Dr. Stein. When the first surveyor returns the work will be compiled.

BOTANICAL SURVEY

BY

CAPTAIN A. T. GAGE, I.M.S., M.A., B.Sc., M.B., F.L.S.,

Director, Botanical Survey of India.

Eastern India.—BENGAL.—Owing to the as yet unorganised and unstaffed condition of the Botanical Survey it was impossible to systematically devote special attention to any particular district in the

province during the year. In the circumstances it was considered better to send Indian collectors to bring in any special groups or families of plants. Thus one man was despatched to the Sunderbuns to collect examples—for distribution to European botanical centres—of such genera as *Sonneratia*, *Kandelia*, *Carapa*, *Ceriops*, *Heritiera*, etc., which exhibit peculiar morphological modifications to adapt them to life under such conditions as exist in the Sunderbuns. Another collector was sent to Western Bengal to collect roots of various species of water lilies, also for distribution to European botanical gardens. The usual collection of plants for the Herbarium and for distribution and of seeds from the high altitudes of the Darjeeling District and Sikkim for distribution to temperate regions of the globe was continued during the year. The Survey has also as in the past been indebted to the Rev. Father Cardon, S.J., of Chota Nagpur, for several interesting photo-geographical discoveries in the way of extensions of the area of distribution of certain species to that part of Bengal.

EASTERN BENGAL AND ASSAM.—In this province a collector was deputed specially to collect the Flora of the district of Mymensingh. Quite recently also Mr. Meebold, the gentleman mentioned in last year's report, has again gone to Manipur on a collecting tour from which the Botanical Survey is to benefit.

BURMA.—By the kindness of Mr. I. H. Burkill, M.A., F.L.S., Reporter on Economic Products to the Government of India, a collector was allowed to accompany him on his tour in the district of Arracan. The vegetation of this district is very imperfectly known, so that interesting results are anticipated when once opportunity of working up the collections occurs. As usual the officers of the Tenasserim Forest Circle contributed interesting and excellent specimens from Lower Burma, while the Deputy Conservator of Forests, Port Blair, contributed a small collection from the Andaman Islands.

Western India.—Mr. G. A. Gammie, the Economic Botanist to the Government of Bombay, has continued his studies of the *Orchidaceæ* of that Presidency, and has also written an account of the vegetation of Bombay Island for the Gazetteer. Mr. Talbot and Mr. Ryan of the Forest Department have continued their botanical work on the same side of India. Considerable collections have been made in Baluchistan by local officers, primarily to determine the economic plant resources of

the country. Those collections which are also of great general botanical interest have been worked out in the Herbarium of the Calcutta Botanic Garden by Mr. I. H. Burkill, the Reporter on Economic Products. A collection of plants, chiefly of economic interest, from Koweit collected by Captain Knox, the Political Agent there, and forwarded by Mr. J. G. Lorimer, I.C.S., C.I.E., has been worked out as far as the material allowed.

Southern India.—The Systematic Assistant to the Government Botanist worked out a large number of South Indian plants collected by Mr. Barber, the Government Botanist, who has been granted leave out of India. The same assistant explored for about three weeks the Nallamalais for root parasites and a general botanical collection, and during the tour discovered a new root parasite. He also worked out barks collected on the Anamalais and the grasses of South Canara, and contributed notes on various botanical subjects to the Reporter on Economic Products, to the Director of Agriculture for Madras, and other officers.

Mr. C. E. C. Fischer of the Forest Department has continued his excellent systematic work in Coimbatore and more recently in North Malabar.

North-West India.—The Herbarium of the Royal Botanic Garden, Calcutta, has been enriched during the year by collections from various parts of the North-West Himalaya made by Mr. I. H. Burkill, Mr. A. R. Tucker of the Imperial Revenue and Agricultural Department, Mr. A. Meebold, and Lieutenant-Colonel J. M. Carpendale, I.A.

From the North-West Frontier Province an excellent collection was presented by Mr. James Marten of the Forest Survey Department, the same officer who formerly did a great deal of work for botanical science on quite the other side of India.

The Survey is indebted to Sir Harold Deane, K.C.S.I., the head of the North-West Frontier Province, for several excellently preserved collections that are particularly interesting in that they show several instances of an eastward extension into India of species hitherto recorded only from the countries to the immediate west of India.

General.—Apart from work done in India systematic Indian Botany has benefited by the loan of Indian Herbarium material of several genera and orders of plants to botanists in Europe engaged in writing special monographs. Thus the Calcutta material of the genus *Arabis*

has been sent on loan to Professor Dietz of Buda-Pesth; of the genus *Bridelia* to Professor Pax of Breslau University; several genera of the natural orders *Amarantaceæ* to Professor Hans Schinz of the University of Zurich. Most of the Indian material of the natural order *Araceæ* is still with Professor Engler, Director of the Imperial Botanical Garden of Berlin.

The Rev. Father E. Blatter, S.J., has studied the interesting problem of the relation between flowering season and climate and has given his results in the Journal of the Bombay Natural History Society. Generally speaking the flowering season appears in the tropics to be practically independent of temperature, but roughly to vary inversely with the amount of humidity, at least in the case of woody plants. The maximum period of flowering of herbaceous plants, however, appears to be towards the latter end of the rainy season.

Mr. Burkill has given considerable attention to the modes of pollination employed by certain Indian plants, which he has described in the Journal of the Asiatic Society of Bengal.

Several physiological researches of interest from the point of view of Indian Botany have been carried out by workers in Europe, some of whom have been furnished with the necessary material from the Calcutta Botanic Garden. These researches are indicated in the list of publications appended to this report so that it is unnecessary to detail them here.

Publications.—Professor Radlkofer's paper on new Eastern Asiatic species of the natural order *Sapindaceæ*, which was referred to in last year's report, has since appeared as Part 3 of Volume III of the Records of the Botanical Survey of India. There is at present in the Press and almost ready to appear in the same publication a *Revision of the Indo-Malayan Species of Cedrela* by M. C. de Candolle, the distinguished botanist of Geneva.

In the Annals of the Royal Botanic Garden, Calcutta, has appeared a systematic monograph on the *Orchids of the North-West Himalaya* by Mr. J. F. Duthie, B.A., F.L.S., formerly Director of the Botanical Department of Northern India and now at Kew. This monograph forms Part II of Volume IX of the Annals and comprises descriptions of all the orchids of the North-West Himalaya with keys to facilitate identification and fifty-eight plates of those species which are not or only imperfectly figured elsewhere. The "*Descriptions of new species*

of Algæ from Burma" by Mr. W. West and Professor G. S. West and Signor Beccari's monograph on the genus *Calamus* are still, it is to be regretted, in the Press. The former, however, is practically ready to appear. Another number of Dr. Cooke's Flora of the Bombay Presidency has appeared which brings his work down to the end of the natural order *Euphorbiaceæ*, while a further instalment of Mr. J. F. Duthie's Flora of the Upper Gangetic Plain has been sent to Press.

No. 19 of the "Materials for a Flora of the Malayan Peninsula" by Sir George King and Mr. J. S. Gamble has appeared during the year. This number comprises descriptions of the genera and the species belonging to the natural orders *Apocynaceæ*, *Asclepiadaceæ* and *Loganiaceæ*.

Several other botanical publications, some of very considerable importance, are referred to in other sections of this report which deal with botanical science from other sides than that of purely survey work. The list of papers appended should give a fair idea of the nature and scope of purely botanical work bearing on Indian botany done during the year either within or outside India.

A list of papers bearing on the Botany of India published during 1906-07.

BEDDOME, R. H. . Crinum amœnum, *Roxb.*, var. Mearsii. (*Gard. Chron., vol. xlii, 27th July 1907, p. 62.*)

BEER, R. . . . On the development of the spores of Helminthostachys zeylanica. (*Ann. of Bot., xx 1906, pp. 177—186, with 2 plates.*)

BERGTHEIL, C., & DAY, D. L. On the cause of "Hardness" in the seeds of Indigofera arrecta. (*Ann. of Bot., 1907, pp. 57—60.*)

BLATTER, E. . . Flowering season and climate. (*Journ. Bomb. Nat. Hist. Soc., xvii, 334, 697, with 5 plates.*)

BLATTER, E. . . The Flora of Aden. (*Journ. Bom. Nat. Hist. Soc., xvii, 4, June 1907.*)

BRAND, A. . . . Additamenta nova ad cognitionem generis Symplocos. (*Bull. Herb. Bois., vi, 1906, pp. 747—750.*)

BRANDIS, SIR D. . Indian trees. An account of trees, shrubs, woody climbers, Bamboos and Palms indigenous or commonly cultivated in the British Indian Empire. *London, 1906, p. xxxiv, 767, with many figures.*

BRANDIS, SIR D. . Remarks on the structure of bamboo leaves. (*Trans. Linn. Soc., vii, 1907, pp. 69—92, with 4 plates.*)

BRANDIS, SIR D. . Mastixia euonymoides *Prain.* (*Ind. For. xxxiii, 1907, p. 57, with 1 plate.*)

BRANDIS, SIR D. . Phœbe Hainesiana *Brandis*, n. sp. (*Hook. Ic. Plant., ix, 4th Ser., pt. I, 1906.*)

BRANDIS, SIR D. . The spruce of Sikkim and the Chumbi Valley. (*Ind. For., xxxii, 1906, pp. 579—581.*)

BURKILL, I. H. . . Alpine notes from Sikkim. (*Kew Bulletin, 1907, pp. 92—94, with 1 plate.*)

BURKILL, I. H. . . Goa Beans in India (*Agri. Ledger No. 4, 1906, pp. 51—64.*)

BURKILL, I. H. . . The pollination of Thunbergia grandiflora *Roxb.* in Calcutta; and the pollination of Corchorus in Bengal and Assam; and also the mechanism of six flowers of the North-West Himalaya. (*Journ. Asiat. Soc., Bengal, ii, pp. 511—525, 1906.*)

BURKILL, I. H., & BOSE, G. C. An abnormal Branch of the Mango (Mangifera indica *Linn.*) (*Journ. Asiat. Soc., Bengal, iii, 6, 1907, June, pp. 427—432*)

CANDOLLE, C. DE Meliaceæ novæ vel iterum lectæ et Rutaceæ novæ. (*Bull. Herb. Boiss., vi, No. 12, pp. 981—986, 1906.*)

CARANO, E. . . Ricerche sulla morfologia delle Pandanacee (*Ann. di Bot., v, pp. 1—46, 1906, with 5 plates.*)

CHIFFLOT, J. . . Anatomie comparée des Barclaya longifolia *Wall.* et Barclaya Mottleyi *Hook.* (*Bull. de la Soc. des Sc. Nat. de Saone et Loire, Sept. to Octr.*)

CLARKE, C. B. . Reductions of the Wallichian herbarium. I, Bignoniaceæ; Pedalineæ. (*Kew Bulletin, 1907, pp. 16—18.*)
II Gesneraceæ. (*Kew Bulletin, 1907, 94—97.*)

CLARKE, C. B. . Reductions of the Wallichian Herbarium. III Cyperaceæ. (*Kew Bull., 7, 1907, pp. 264—281.*)

COOKE, T. . The Flora of the Presidency of Bombay, Vol. ii, Part iii, *Verbenaceæ—Euphorbiaceæ.*

COTTON, A. D. . New or little-known marine Algæ from the East. (*Kew Bull., 7, 1907, pp. 260—264, with plate.*)

DEMILLY, I. . Les plantes du genre Laportea *Gaudich.*, leur caractères, leur action urticante dangereuse. (*Bull. Sc. Pharmacol, xiii, p. 144, 1906.*)

DEY, SURENDRANATH . A short account of the seeds and oil of Cochlospermum Gossypium. (*Agri. Ledger, 1906, pp. 65—68.*)

DIELS, L. . Die primitivste Form von Lygodium. (*Hedwigia, xliv, 1905, pp. 133—136.*)

DIELS, L. . Droseraceæ. (*Das Pflanzenreich, IV, No. 112, 1906.*)

DIHM, H. . Das Blatt der Gattung *Meliosma* (Sabiaceen) in anatomischer Hinsicht. with 2 plates.

DOP, P. . Physiologie des mouvements des étamines de Mahonia nepalensis *DC.* (*Bull. Soc. Bot. France, 1905, p. 136.*)

DRABBLE, E. . The Transition from stem to root in some palm seedlings. (*New Phytologist, v, 1906, pp. 56—66, with 7 figs.*)

DRUMMOND, J. R. . Chlamydites: A new genus of Compositæ. (*Kew Bulletin, 1907, pp. 90—92.*)

DRUMMOND, J. R., & PRAIN, D. Notes on Agave and Furcræa in India. (*Bengal Agric. Bulletin No. 8, 1906.*)

DUTHIE, J. F. . . The Orchids of the North-Western Himalaya. (*Ann. Roy. Bot. Gard., Calcutta, ix, Part II, pp. i—ii, and 81—211, with 58 plates.*)

ELLIS, E. V. . . Cephalostachyum pergracile in flower. (*Indian Forester, xxxiii, 7, July 1907, pp. 323—324.*)

FINET ET GAGNEPAIN . Espèces nouvelles de l'Asie Orientale. (*Bull. Soc. Bot. France, liii, pp. 573—576, 1906, with fig.*)

GAGE, A. T. . . The varieties of Bombax insigne *Wall.* in Burma. (*Ind. For., xxxiii, No. 3, 1907.*)

GAGE, A. T. . . Sktech of the Herbaceous Vegetation of Burma. (*In Sir George Scott's "Burma," 1906.*)

GAGNEPAIN, F. . Zingiberacées nouvelles de l'herbier du Muséum. (*Bull. Soc. Bot. France, 1906, liii, pp. 351—356.*)

GAMBLE, J. S. . Gutta-percha trees of the Malay Peninsula. (*Kew Bulletin, 1907, No. 4, pp. 109—121.*)

GAMMIE, G. A. . . The orchids of the Bombay Presidency, Part iii. (*Journ. Bom. Nat. Hist. Soc., xvii, 31, with plate.*)

GATIN, C. L. . . Nouvelle contribution à l'étude chimique de la germination du Borassus flabelliformis. (*Rev. Gen. Bot., xviii, 216, pp. 481—483.*)

GUENOT, J. F. . . Contributions à l'étude anatomique des Pittosporaceæ. (*Thèse, Paris, 1906.*)

GUERIN, P. . . Cellules à mucilage des Dipterocarpées. (*Bull. Soc. Bot. France, liii, pp. 443—451, 1906.*)

HAINES, H. H. . . On two new species of Populus from Darjeeling. (*Journ. Linn Soc., xxxvii, No. 262, pp. 407—409, 1906, with text figs.*)

HEMSLEY, W. B. . Nepenthes Macfarlanii *Heml.* (*Hook. Ic. Plant., ix, 4th Ser., pt. I, 1906.*)

HILL, A. W. . . A revision of the geophilous species of Peperomia, with some additional notes on their morphology and seedling structure. (*Ann. of Bot., 1906, xxi, pp. 139—161, with 1 plate.*)

HOLE, R. S. . . "What is a species?" (*Journ. Bom. Nat. His. Soc., xvii, 4, June 1907.*)

HOOKER, SIR J. D. . Triomma malaccensis, *Hook. f.* (*Hook. Ic. Plant., ix, 4th Ser., pt. I, 1906.*)

HUTCHINSON, J. . Gentiana ornata. (*Bot. Mag., iii, No. 30, 1907.*)

JAENSCH, O. . . Betrag zur Embryologie von Ardisia crispa *A. DC.* (*Dissert. Breslau, p. 35, 1905.*)

KANNGIESSER, F. . Blattziechnungen bei Oxalis acetosella. (*Gartenflora, 1906, p. 441.*)

KINDERMANN, V. . Zur Anatomie und Biologie des Samens von Hydrocharis Morsus-Ranæ. *L.* (*Lotos. Prag. Bd., xxvi, No. 4, 1906, pp. 105—109.*)

KOOP, H. . . Anatomie des Palmenblattes mit besonderer Berucksichtigung ihrer Abhangigkeit von Klima und Standort. (*Beihefte Bot. Centralblatt, Band xxii, Abt. 1, Heft 2.*)

KRYZ, F. . . . Ein Beitrag zur Kenntnis der Variation der Frucht von Trapa natans *L.* (*Oesterr. Bot. Zschr., 1907, lvii, 6, pp. 185—193, 9 figs.*)

LITSCHAUER, V. . . Beitrag zur Kenntnis der eingesenkten epidermalen Drüsen bei Polygonum Hydropiper *L.* (*Oesterr. Bot. Zschr. 1907, lvii, 5, pp. 201—204.*)

MAHEN, J. . . . Sur les organes secreteurs des Menispermacées. (*Bull. Soc. Bot. France, 1906, pp. 651—663.*)

MONTEIL, P. . . Anatomie comparée de la feuille des Chenopodiacées. (*Trav. Lab. Mat. Med. Ecole Sup. Pharm. Paris, iv, 156, p. 41. fig., 1907.*)

MUTH, FR. . . Untersuchungen über die Früchte des Hanfes. (Cannabis sativa *L.*) (*Jahrbuch der Vereinig. Vertreter angewand. Botanik Berlin, 1906, pp. 76—122, with 1 plate.*)

POND, R. H. . . The Incapacity of the Date endosperm for self-digestion. (*Ann. of Bot., pp. 62—78, 1906.*)

PRAIN, D. . . . Dalbergia Lacei *Prain* (Leguminosæ-Dalbergieæ). (*Kew Bull., 2, 1907, pp. 58—59.*)

REED, H. S. & SMOOT, I. The mechanism of seed-dispersal in Polygonum virginianum. (*Bull. Torrey Bot. Club, xxxiii, pp. 377—386, 1906.*)

RIDLEY, H. N. . . Materials for a Flora of the Malayan Peninsula—Monocotyledones, Parts i—iii.

SCHLOTTERBECK, J. O. & ECKLER, C. K. The development and structure of the seed of Argemone mexicana. (*Proc. Amer. Pharm. Ass., 1906, civ, pp. 466—469, pl. 2.*)

SCHNEIDER, C. K. . Die Gattung Berberis (Euberberis). (*Mett. d. deutsch. dendrolog. Gesellsch. Heft. 15, pp. 111—124, 1905.*)

SCHOUTE, J. C. . . Uber die Verästelung bei monokotylen Bäumen. I. Die Verästelung von Pandanus. (*Ann. du Jard. Bot. de Buitenzorg, xx, pp. 53—87, 1905, with 27 figs.*)

SOAVE, M. . . . Il ferro nella Trapa natans. (*Ann. Acc. Agri. Torino., xlviii, pp. 409—415.*)

SPLENDORE, A. . . Sinossi descrittiva ed iconographica dei semi del genere Nicotiana. (*Portici, 1906, p. 163, with 60 plates.*)

SPRENGER, C. . . Die Crinum Asiens. (*Osterreich Garten-Zeit. Wien, 1906, Heft 10, pp. 361—366.*)

STAPF, O. . . The Oil grasses of India and Ceylon. (*Kew Bulletin, 1906, pp. 297—363, with plate.*)

STAPF, O. . . . Aconitum Gammiei *Stapf* (Ranunculaceæ) (*Kew Bull., 2, 1907, pp. 56—57.*)

STAUB, M. . . . Die Geschichte des Genus *Cinnamomum.*

STOPES, M. C. . . On the double nature of the Cycadean Integument. (*Ann. of Bot., xix, pp. 561—566, 1905.*)

SVEDELIUS, N. . . Reports on the Marine Algæ of Ceylon. No. I. Ecological and Systematic Studies of Ceylon species of Caulerpa. (*Ceylon Marine Biological Reports, ii, No. 4, 1906, pp. 81—144, with 51 figs. in text.*)

SVEDELIUS, N. . . Uber die Aehnlichkeit zwischen der Marinen Vegetation Westindiens und des indischen und stillen Ozeans. (*Botaniska Notiser, 1906, pp. 49—57.*)

TODD, F. H. . . Pterocarpus dalbergioides. (*Ind. For., xxxii, No. 12, pp. 581—587, 1906.*)

TREUB, M. . . L'Apogamie de l'Elatostemma acuminatum. *Brongn.* (*Ann. du Jard. Bot. de Buitenzorg, v, 2 Ser., pp. 141—152, 1905.*)

VIGUIER, R. . . . Recherches anatomiques sur la classification des Araliacées. (*Ann Sc. Nat. Bot., iv, 1906, pp. 1—208.*)

WALTER, H. . . Die Diagramme der Phytolaccaceen. (*Engler's Bot. Jahrb., xxxvii, 1906, 4th Heft. Beibb. 85, pp. 1—57.*)

WEHNERT, A. . . Anatomisch-systematische Untersuchung der Blätter der Gattung "Symplocos." Diss. Munchen, 1906, p. 57.

WILLIAMS, F. N. . On the genus Clarkella (Rubiaceæ). (*Journ. of Bot., xliv, pp. 377—399, 1906.*)

WILLIS, J. C. . . The Progress of Botanical and Agricultural Science in Ceylon. (*Science Progress, i, pp. 308—324, 1906.*)

YAPP, R. H. . . Fruit-dispersal in Adenostemma viscosum. (*Ann. of Bot., xx, 1906, pp. 311—316, with plate.*)

AGRICULTURAL BOTANY

BY

E. J. BUTLER, M.B., F.L.S.,
Imperial Mycologist.

Foods.—The botanical study of the cereals mentioned in the last report—wheat, juar, rice and barley—has not yet reached the stage of publication but is still in progress. No publications of botanical importance have been issued in connection with Indian cereals during the year. Agricultural Ledgers on the races of juar and on the rice, *Oryza coarctata*, are promised shortly by Mr. Burkill, Reporter on Economic Products. Mr. Howard, Imperial Economic Botanist, has a large monograph of Indian wheats under preparation. This is based on representative collections grown and isolated at Pusa and Lyallpur, as typifying the Eastern and Western Indo-Gangetic areas, extended by field observations in other tracts. The classification of Indian wheats is completed. A number of successful crosses have been obtained at Pusa and Lyallpur, and wheat-breeding work is proceeding at these stations on Mendelian lines. The botanical enquiry into Indian barleys has been made over by the Reporter on Economic Products to Mr. Howard, who has commenced the preliminary work at Pusa.

Mr. Barber has continued his work on sugarcane in South India. Special attention has been paid to the origin of sugarcane varieties. An account of their origin by " sporting " or bud-variation, in certain cases observed at the Samalkota Farm, has been published. Some of the sports have proved of exceptional quality and have been segregated and cultivated. They have originated only from striped canes, and this is held to indicate that the striped varieties are in reality hybrids between two canes of different colours. At the last meeting of the Board of Agriculture the whole question of the improvement of the Indian sugarcane industry was discussed. A number of papers on the

subject was laid before the Board, and from these it may be gathered that, although the agricultural characters of Indian sugarcanes have been investigated in some provinces, notably by Khan Bahadur S. M. Hadi in the United Provinces, no real botanical work with them has yet been attempted in this country. Though seedling canes have actually been raised, they have never reached the experimental stage, and this immensely important line of work has yet to be undertaken in India. Individual selection for yield and quality of juice is another promising direction awaiting attention. The ground has, however, been cleared for future work, as soon as the botanical staff becomes strong enough to undertake it.

The reports on Indian yams, caraways and Burmese pulses, referred to in last year's report, are still in preparation ; enquiries are also being continued regarding chillies, pan (Piper Betel), plantains and kessary (*Lathyrus sativus*) by the Reporter on Economic Products.

Mr. Burkill has published a Ledger on Goa beans (*Psophocarpus tetragonolobus*), which gives the history, distribution and characters of the pulse in India. Another Ledger has been written by Mr. D. Hooper on the food value and uses of the root of *Costus speciosus*. The identity of the common root of the Calcutta market called " Singapuri kesur " was determined by Mr. Burkill, who has found it to be the root of *Eleochairs tuberosa*, the Chinese " Pe-tsi " or " Ma-tai."

A series of experiments designed to throw light on the behaviour of Indian fruit trees under different conditions and treatment has been initiated by Mr. Howard at Pusa. A first report on these has been published, giving details of the main lines of work.

Fibres.—A large and important work on the cottons of the world by Sir G. Watt is announced. The memoir on Indian cottons by Professor Gammie, referred to in last year's report, is now in the Press. Mr. Fletcher, Deputy Director of Agriculture, Bombay, has published a preliminary note on Bombay cottons. From this it appears that considerable progress has recently been made in introducing exotics, especially Egyptian cotton, in Sind. Sea Island cotton of good quality was grown at Karachi in 1906. Tree cottons of the " rough Peruvian " (? *G. peruvianum*) and Bourbon (? *G. barbadense*) types are being grown in the Karnatak and Ahmedabad-Kaira tracts, respectively. A large collection of tree cottons is maintained at Poona for botanical investigation by Professor Gammie, who has prepared a preliminary

classification of the main types. Mr. Fletcher records that at least one extremely promising hybrid cotton has been reared on the Surat Farm, and remarks that this hybrid, No. 1027 A, will, if it preserves its good qualities, be worth many times more than the whole expenditure on the Surat Farm since its commencement. A memoir on the cotton known as *Gossypium obtusifolium* Roxb. has been published by Mr. Burkill, and the same author has furnished a note on the pollination of the cotton plant, which tends to confirm the conclusion previously reached by Professor Gammie, that cross-fertilization and natural hybridization are rare in cultivated members of this genus.

A review of the Indian Agaves has been published by Mr. J. R. Drummond and Lieutenant-Colonel Prain, as Agricultural Ledger No. 7 of 1906. The more important features of this work, from our point of view, are the following. *Agave americana* is apparently not a naturalized plant in any part of India, but is merely grown in gardens as an ornamental plant. It disappears therefore as a name for any plant yielding commercial fibre in India. Where *A. americana* has been spoken of in previous Indian literature some other species is almost always intended. This is often *A. Cantala*, which gives good fibre and is largely exported, mixed with others, as "Bombay aloe fibre." All told ten species have been separated in the course of this enquiry, of which six are identified and the remaining four are not at present identifiable owing, in great measure, to the extraordinarily confused condition of the literature on the subject. Besides *A. Cantala* three other species are of economic importance in India according to present knowledge, *viz.*:—*A. sisalana*, a comparatively recent introduction, *A. Wightii*, which has the disadvantage of being short leaved, and an unidentified species called temporarily by the authors *A.* "*species F.*" Three, *A. americana*, *A. decipiens* and *A.* "*species C.*," are only known in India as ornamental plants or in herbaria as dried specimens. One, *A.* "*species A.*," has only been obtained during the enquiry from Burma, but is probably cultivated at the Saharanpur Botanical Garden. Of the remaining two nothing is really known about the fibre, but *A.* "*species H.*" is the finest plant of the naturalized species, with leaves 7 or 8 feet long, is widely distributed and, it is believed, would repay careful investigation; while *A. Vera Cruz* is less likely to be profitable. Further, two species of plants yielding Mauritius hemp occur in India, where previously but one (commonly called *Furcræa gigantea*) was

supposed to exist. Owing to the difficulty of determining which of these was referred to by the older botanists, the authors have contented themselves with calling them species 1 and 2.

Mr. Burkill is still engaged in his botanical study of the races of jute. A first outcome is a "Note on the pollination of *Corchorus* in Bengal and Assam." Contrary to a previous assertion, insects were found freely visiting the flowers. Hybridization between the different races is, however, not a frequent result. Part of the jute work is in collaboration with Mr. R. S. Finlow, Fibre Expert to the Government of Eastern Bengal and Assam. It is in continuation of the investigation started by the Sub-Committee of this Board in 1904 and is preliminary to further work involving selection and possibly hybridization. An account of what has been done so far is now in the press. Mr. Finlow has in conjunction with Mr. C. Bergtheil, Imperial Bacteriologist, carried out a series of experiments with seeds of several fibre-yielding jungle plants, which show the character of delayed germination. These have all responded to the sulphuric acid treatment for hardcoated seeds referred to in last year's report, and again below, under "dyes."

Experiments with Sunne hemp (*Crotalaria juncea*) were continued at the Royal Botanic Garden, Calcutta. The fibre grown from races received from different parts of India has been extracted and sent to London for valuation

The fibre garden at Pusa under Mr. Howard has been brought into working order and experiments with a number of species of fibre plants have been commenced.

Oils, dyes, drugs, etc.—An important monograph on the oil grasses of India and Ceylon by Dr. O. Stapf of Kew was recently published in the Kew Bulletin. Twelve oil-yielding species are described, all but one occurring in India. Of these, the important commercial species in India are the following:—*Cymbopogon flexuosus*, the source of Cochin or Malabar Lemon-grass oil; *C. citratus*, the source of Lemon-grass oil proper, inferior to the preceding but widely cultivated in Indian gardens; *C. Martini*, the source of the Rusá oil of Khandesh and the Central Provinces; and *Veteveria zizanioides* (*Andropogon muricatus* Retz), the "khas khas" grass, the roots of which are extensively used in the preparation of perfumes in India and are exported to Europe for extraction of the oil. The products of these grasses are being investigated by the Indian Museum, in conjunction with Messrs. Schimmel

& Co., of Miltitz near Leipzig. The enquiry into possible sources of camphor from Burmese species of *Cinnamomum*, mentioned last year is being prosecuted by the Reporter on Economic Products.

Messrs. Bergtheil and Day contributed a paper to the Annals of Botany on the cause of "hardness" in the seed coats of *Indigofera* arrecta. As mentioned in last year's report, the difficulty encountered in germinating the seed of this species, the Java or Natal indigo which is so rapidly extending in cultivation in Behar, was overcome by a method elaborated by Mr. Bergtheil, which consists in treating the seed with strong sulphuric acid. The cause of delayed germination is attributed in the present paper to the existence of an outer, very thin covering of a substance resistant to water. The exact nature of this substance was not determined, but it appears to be a body intermediate between cellulose and cuticle. Sulphuric acid swells it and makes it permeable to water, while the older method of scarifying the seed ruptures it. Further investigations have been carried out by Mr. Bergtheil at the Sirsiah Indigo Research Station on the superiority of first crop over rattoon plants for seed purposes, the best method of preserving the vitality of Java indigo seed, the indigotin content of various species of *Indigofera* and preliminary work in isolating the chief types of the Sumatrana plant, with a view to selection. Trials of soil inoculation with the nodule bacilli of the legume family at this station have confirmed with indigo the results already obtained in other parts of India with other crops, that no benefit results from the practice with common Indian crops.

Mr. Burkill has commenced a botanical examination of Nepalese Aconites in connection with Professor Dunstan's work on Indian sources of the drug. Mr. Howard is engaged on a botanical study of Indian tobaccos, including an investigation of the biology of the flower and the extent to which variation takes place.

Miscellaneous.—An account of acclimatization work carried out at the Saharanpur Botanical Garden, compiled by the late Mr. W. Gollan, was published as a Bulletin of the Department of Agriculture, United Provinces. It contains a mass of information regarding the results of trials of a large number of exotic plants of economic value. Mr. F. G. Sly, Officiating Inspector General of Agriculture in India, contributed a history of the attempts to establish exotic drought-resisting plants in India, to the Agricultural Journal of India. The conclu-

sion arrived at after a survey of the various trials is in agreement with the opinion expressed by Lieutenant-Colonal Prain, recently Director of the Botanical Survey of India, that there is much more promise in the extension of indigenous salt bushes and other plants than in trials of exotics.

Mr. Fletcher, recently Deputy Director of Agriculture, Bombay, has carried out a series of experiments tending to show that the roots of plants excrete an auto-toxic substance during growth. A memoir giving details of the work is in the Press.

Mycology and plant pathology.—An account of the "red rust" of tea caused by the interesting alga, *Cephaleuros virescens*, was published by Dr. H. Mann and Mr. C. M. Hutchinson, of the Scientific Department of the Indian Tea Association. This is a technical account of the authors' work, the chief practical results of which have already been published.

The first part of a series entitled "Fungi Indiæ Orientalis" has been issued by Messrs. H. and P. Sydow of Berlin in conjunction with the writer. This contains technical descriptions with notes of 143 species of parasitic rusts and smuts, of which one genus and 42 species are new to science. A second instalment, completing these groups as far as they are represented in the Pusa Herbarium and including the *Phycomycetes*, in all about 200 species, has been worked out and will shortly be published. This is the first attempt at a systematic account on a large scale of the Indian fungus flora. The monograph on the *Pathiaceæ* referred to last year has been published. The chief species of economic importance in India is *Pythium palmivorum*, a destructive parasite of palms. A more popular account of the disease caused by this fungus and some other palm diseases was published in the "Agricultural Journal of India." Operations in its prevention are in progress in the Godavari Delta, under a special establishment sanctioned by the Government of Madras.

A curious group of cereal diseases, producing floral malformations and sterility in several important crops, was studied and its cause ascertained to be the parasitic Phycomycete, *Sclerospora graminicola*. An account of these diseases, which may at any time become epidemic, was published. Attempts to raise wilt-resisting varieties of pigeon-pea are in progress at Poona, and are promising well. Treatment of the ticca disease of ground-nut by spraying and steeping, at the same

locality, has proved unsatisfactory, and the only hope of reducing the losses caused by this disease appears to be the raising of early maturing and resistant varieties. Work is well advanced on the group of wilt diseases in India caused by *Neocosmospora vasinfecta* and affecting cotton, pigeon-pea, gram, indigo and other crops. The full investigation will take some years to complete. Another troublesome investigation, as yet incomplete, is that of an orange disease prevalent in Sylhet and Burma. Work with sugarcane diseases, wheat and other rusts, and a number of other crop diseases, was continued by the writer.

The trials of the South African Locust fungus carried out by the writer in conjunction with the Imperial Entomologist were completed and a report issued. This much-vaunted method of destroying locusts has proved absolutely useless. Recent work in South Africa itself gives a sufficient reason for this. The fungus distributed by the South African authorities (and which was employed in India) has been ascertained to be quite different to the actual locust parasite, and is probably an accidental contamination from the first prepared tubes. This fact escaped detection until now, owing to the absence of any mycologist on the spot until recently. It is doubtful if the true locust parasite in the Transvaal can be artificially cultivated, but attempts are being made on the spot,. and, if successful, the work can be repeated under better auspices in India.

List of publications dealing with Indian Agricultural Botany in 1906-07.

BOARD OF AGRICULTURE IN INDIA.	Proceedings for 1907.
BARBER, C. A. . .	The origin of new sugarcanes by "bud-variation." *Agric. Jour. of India*, Vol. I, pt. 4, October 1906.
BERGTHEIL, C. . .	Report of the Indigo Research Station, Sirsiah, for the year 1906-07.
BERGTHEIL, C., AND D. L. DAY.	On the cause of "Hardness" in the seeds of Indigofera arrecta. *Annals of Botany*, XXI, 57, 1907.

BURKILL, I. H. . . Report and Programme of Collections for the Indian Museum, Calcutta, and the Imperial Institute, London, for 1907.

BURKILL, I. H. . . Gossypium obtusifolium, Roxburgh. *Mem. Dept. of Agric. in India,* Botanical Series, Vol. I, No. 4, August 1906.

BURKILL, I. H. . . Psophocarpus tetragonolobus (Goa bean). *Agric. Ledger,* No. 4 of 1906.

BURKILL, I. H. . . Notes on the Pollination of Flowers in India. Note No. 2. The Pollination of Corchorus in Bengal and Assam; and Note No. 4. On Cotton in Behar. *Jour. and Proc. Asiat. Soc. Bengal,* new series, Vol. II, No. 10, 1906, and Vol. III, No. 7, 1907.

BUTLER, E. J. . . Some Diseases of Palms. *Agric. Jour. of India,* Vol. I, pt. 4, October 1906.

BUTLER, E. J. . . An account of the genus Pythium and some Chytridiaceæ. *Mem., Dept. of Agric. in India,* Bot. Series, Vol. i, No. 5, February 1907.

BUTLER, E. J. . . Some Diseases of Cereals caused by Sclerospora graminicola. *Mem., Dept. of Agric. in India,* Vol. ii, No. 1, March 1907.

BUTLER, E. J., AND H. MAXWELL-LEFROY. Report on Trials of the South African Locust fungus in India. *Bull. of Agric., Research Institute, Pusa,* No. 5, March 1907.

BUTLER, E. J. . . The selection of sugarcane cuttings. *Agric. Jour. of India,* Vol. ii, pt. 2, April 1907.

DRUMMOND, J. R., AND D. PRAIN. Agave and Furcræa spp. Notes on Agave and Furcræa in India. *Agric. Ledger,* No. 7, of 1906.

FINLOW, R. S. . . The extension of Jute cultivation in India. *Bull. of Agric. Research Institute, Pusa,* No. 3, July 1906.

FLETCHER, F. . .	Preliminary note on Bombay Cottons. *Bull., Dept. of Agric., Bombay*, No. 29, 1906.
GOLLAN, W. . .	Some results of Acclimatization work at the Saharanpur Botanical Gardens. *Bull., Dept. of Agric., United Provinces*, No. 21, 1906.
HOOPER, D. . .	Costus speciosus. The uses and value of the root of Costus speciosus as a food stuff. *Agric. Ledger*, No. 2, of 1906.
HOWARD, A. . .	First Report on the fruit experiments at Pusa. *Bull. of Agric., Research Institute, Pusa*, No. 4, 1907.
MANN, H., AND C. M. HUTCHINSON.	Cephaleuros virescens, Kunze, the "red rust" of Tea. *Mem., Dept. of Agric. in India*, Vol. i, No. 6, April 1907.
SLY, F. G. . . .	The trial of Exotic drought-resisting plants in India. *Agric. Jour. of India*, Vol. ii, pt. 2, April 1907.
STAPF, OTTO. . .	The Oil-grasses of India and Ceylon. *Kew Bull.*, 1906, No. 8.
SYDOW, H. AND P., AND E. J. BUTLER.	Fungi Indiæ Orientalis, pt. i. *Annales Mycologici*, Vol. iv, No. 5, 1906.

FOREST BOTANY

BY

R. S. HOLE,
Imperial Forest Botanist.

Anatomy.—1. The most important research under this head, dealing with Forest Botany carried out during the year, is that comprised by Dr. Barber's investigations into the haustoria of Sandal.[1]

Forest Floras.—2. By far the most important publication issued during the year is that entitled *Indian Trees*. This comprehensive

[1] Memoirs of Department of Agriculture in India, Botanical Series, Vol. i, No. i, Part ii.

work will be the standard book of reference for Forest Officers for many years to come and will be of the greatest use in the preparation of local forest floras which was one of the chief of the author's aims in its compilation.

Mr. Haines was engaged during the year on the preparation of the Flora of Chota Nagpur. A preliminary list of the trees, shrubs and climbers found in the Northern Circle of the Central Provinces, by the writer, was published by the Local Government during the year.

Mr. Witt was engaged during the year on the preparation of a list of species found in the Berar Circle of the Central Provinces, based on the list originally prepared by Mr. Dickinson and added to by Mr. Ballantyne.

Limitation of Species.

3. A paper dealing with the possibility of adopting a generally acceptable definition of the word species was contributed by the writer during the year.[1]

Culture experiments, carried out for the purpose of testing the validity of the claims of particular plant forms to rank as species, are unfortunately difficult in the case of trees, owing to the long periods of time required, but it seems probable that good results would be obtained if more attention were paid to the careful study of large sets of specimens, each set having been collected from one and the same individual tree. In last year's report the remarkable dimorphism of the twigs and leaves of *Populus Gamblei* was alluded to. A silvery-pubescent form of *Anogeissus latifolia* is also not uncommon which, when first seen, might be held to be a distinct species, but the writer has found branches of this variety on a tree of the ordinary type.

New Species.

4. Sir D. Brandis has a note on an undetermined species of *Picea* found in Sikkim and the Chumbi Valley.[2]

Captain Gage has a paper on the varieties of *Bombax insigne* Wall.[3] *Populus glauca* Haines mentioned in last year's report has been noticed by Messrs. Arber and Parkin in their interesting paper

[1] Journal of the Bombay Natural History Society, Vol. xvii, No. 4, p. 930.

[2] Indian Forester, Vol. xxxii, p. 579.

[3] Indian Forester, Vol. xxxiii, p. 115.

on the origin of the Angiosperms.[1] The frequent occurrence of bisexual flowers and of an undoubted perianth in this species are held to indicate that *Populus* is the older genus and that *Salix* has probably been derived from a Poplar-like ancestor.

Establishment of forest Herbaria and Collection of Specimens.

5. Mr. B. B. Osmaston reports that a forest herbarium has been started in the Andamans, a large number of specimens of the trees and shrubs of the Andamans, collected both by Mr. Osmaston and his predecessors, having been classified and properly arranged in glazed almirahs obtained from Sibpur.

Mr. Osmaston has also very kindly sent 260 duplicate sheets for incorporation in the herbarium of the Imperial Forest College at Dehra Dun. A considerable amount of work was done in the latter herbarium by the Forest Botanist during the year. Up to the date of this report some 700 sheets have been added, among the principal contributors being Messrs. Haines, Lace, Osmaston, Haslett, Witt, Modder, Long and Keshavanand. The identification of all specimens received by the Forest Botanist were communicated where necessary and help was afforded to the compilers of local lists.

Mr. D. A. Thompson has made a collection of the grasses found in the forests of Panch Mahals.

A reference collection of wood specimens was commenced for the Museum of the Forest School at Balaghat, Central Provinces, and Mr. Clutterbuck has started a similar collection for the Kheri Division.

Distribution of Species.

6. Observations on the distribution of important forest species in the various districts and divisions are greatly needed. And no doubt Forest Officers will afford valuable assistance in collecting data on this point so that maps showing the detailed distribution of the various species may be prepared in the Forest Research Institute. Until this has been accomplished discussions regarding the factors which influence the distribution of Indian trees must remain to a great extent profitless.

Interesting, from the point of view of distribution, are the finding of *Mastixia Euonymoides* Prain, in British Bhutan,[2] of *Vitex*

[1] Journal Linnean Society, Vol. xxxviii, p. 41.

[2] Indian Forester, Vol. xxxiii, p. 57.

glabrata by Mr. Haines in the Sonthal Parganas and of a species of *Berberis* wild on the hills near Pachmarhi by the writer.

Periodicity.

7. Mr. Cubitt reports interesting instances from the Bhamo Division, Burma, in which young teak trees with a fairly advanced new flush of leaves have been found in May, growing side by side with old trees on which there were still large numbers of vigorous old leaves. The factors which influence the periodic shedding of leaves and the production of new foliage in our Indian trees require careful investigation. In some cases the temperature and in others the moisture of the soil appears to exercise the most important influence, while it has been noticed that deciduous species in a forest which has been burnt over frequently come into leaf earlier than elsewhere. The whole question is connected more or less closely with the formation of annual rings of growth and the quality of the wood and is therefore of importance.

As regards annual rings, Mr. McIntire (Conservator, Bengal) reports interesting results of experimental ring countings on sections of Sal coppice shoots, 10½ years old, in the Sonthal Pargana Division which "proved that the ages of such shoots in dry localities could be accurately determined by counting these rings." Mr. McIntire also notes that "observations of rings on fresh cut stumps in the Kurseong Terai (climate very damp) appeared to show that the rings accurately show the ages of trees in that locality, at any rate until they are 60 to 100 years old."

Asexual Reproduction.

8. The subject of reproduction being of such great importance in Forestry considerable attention has been paid to it by Forest Officers generally.

The writer contributed a paper on Coppice Shoots [1] in which the necessity is emphasized of distinguishing between, first, those cases in which the young shoots develop a root-system of their own and become independent of the parent, as often occurs apparently in the case of root-suckers and also possibly in the case of some stool-shoots, and secondly, those cases in which the young shoots are entirely dependent on the parent stump, as is the case with pollard-shoots. In the first we are dealing with cases of more or less complete reproduction and

[1] Indian Forester, Vol. xxxii, p. 334.

in the second with cases of more or less complete recovery of one and the same individual from a severe injury.

An important point in coppice forests is whether or not the "coppice-shoots" are able to produce fertile seed. Experiments carried out by Messrs. Tulloch and Gulab Rai in the Bahraich and Gonda Divisions of the United Provinces, so far as they go, indicate that the seed of Sal coppice shoots is fertile, but the results of these experiments will, it is hoped, soon be published in detail. Meanwhile, the following small experiment conducted by the writer during the year while on leave in England, may be mentioned as being of interest, although it refers to the European species *Quercus pedunculata*. Some 40 acorns were collected at random from a seedling tree and a similar number from coppice stems, and from each batch 15 of the best were sown. Of each set of 15 acorns, 14 germinated and produced healthy plants and there was one failure. This case is noticeable because the coppice stems were obvious stool-shoots with no independent root-system. They were only eight feet high and about eight years old, but they sprang from a very old stool which was in great part decayed, and their acorns were fully fertile. Further observations on our Indian species referring to the different types of shoots are badly needed. Whatever the disadvantages of asexual reproduction may be, the fact should not be forgotten that it usually produces plants which, at all events at first, grow more vigorously and attain large dimensions quicker than do those developed from seed. This power of vigorous growth may often be of vital importance for the existence of the plant, *e.g.*, in areas which become quickly covered with a heavy growth of grass, in which the slow-growing young seedlings of forest trees are often smothered and killed, whereas strong-growing root-suckers may be able to establish themselves. Evidence that this has happened is afforded in many parts of India where practically pure forests of *Ougeinia dalbergioides* and *Diospyros tomentosa* (both species which produce root-suckers freely) now occupy the sites of abandoned fields.

Mr. McIntire notes that "other things being the same, coppice reproduction is far less satisfactory in the damp climates of the terai and of the Darjeeling hills than in the relatively dry climates of Chota Nagpur, Orissa, etc. In the damp climates cutting so as to leave stumps a few inches high seems to be more favourable for coppice reproduction than cutting level with the ground."

Mr. Clutterbuck has also noticed that "Sal, cut level with the ground and the stumps dressed, gives very poor results in the way of coppice shoots. In fact the greater proportion of trees above one foot in girth give no shoots at all. This appears to be due to the contraction of the wood (Sal being particularly liable to such shrinkage) causing the wood near the surface of the stump to part from the bark. The cambium is in this way killed to a depth of three or four inches below the ground. The dormant buds appear to exist chiefly in this region, and thus no shoots appear. It is probable that this could be remedied by cutting the trees about four inches above ground. The portion above ground then would dry up and coppice shoots would be produced in abundance from ground level."

Sexual Reproduction.

9. Mr. Pearson contributes an interesting paper on *Anogeissus latifolia*[1] and comes to the conclusion that this species rarely produces large quantities of fertile seed except under unusual conditions, *e.g.*, after drought.

In addition to the climatic factors which influence the production of fertile seed, observations are badly needed, regarding the methods employed by our forest species to ensure the fertilisation of their flowers. It is possible that the failure to produce fertile seed may in some cases be due to the failure to secure cross-fertilisation, and if so it is possible that we might do something to help the birds or insects which are instrumental in securing cross-fertilisation and thus good crops of fertile seed.

Mr. Clutterbuck notes that it was a record year for an abundance of Sal flower and seed and draws attention to the coincidence of there being unusual falls of rain in February, March, April.

Pathology.

10. Mr. Monro has made some observations on the damage done by *Trametes pini* in the forests of *Pinus excelsa* of the Simla Division. Trees which have been lopped or wounded are mainly attacked and the fungus can apparently only attack a healthy tree through the medium of a wound unprotected by resin, as is the case in Europe. Mr. Rogers (Conservator, Berar) reports that *Fomes Pappianus*, which at one time was believed to be doing serious damage to the Babul (*Acacia arabica*)

[1] Indian Forester, Vol. xxxiii, p. 231.

forests of Berar, is no longer giving cause for anxiety. Mr. Rogers also notes that Anjan (*Hardwickia binata*) seedlings are particularly liable to damage by grazing, owing to the fact that the young leaves appear in the hot season when fodder is scanty. The seedlings which survive in grazed areas are usually protected by armed shrubs, such as *Zizyphus sp.*

Although the damage done by plant parasites appears happily to be comparatively small, the great injury inflicted by plant competitors is becoming more and more prominent. Messrs. McIntire, Lovegrove and E. M. Coventry have alluded to the injurious competitive effect of the inferior species often associated with Sal.

The competition between tree species and grasses is severe and particularly so during early youth, owing to the fact that so many of our valuable forest species, for the first few years of their existence, only show a very insignificant development of the shoot above ground and have little chance of surviving in the struggle for existence with a dense growth of grasses which effectually shuts out the necessary light.

With the object of helping the tree species two plans are not infrequently resorted to:—

(1) The sowing of tree seeds with low-growing field crops, the injurious competitive action of which is less injurious than that of grasses, while the cultivation prevents the development of the grasses.

(2) Keeping down the grass-growth by grazing.

Mr. L. S. Osmaston contributes an interesting account of successful operations of the first class,[1] and regarding the second plan Mr. Rogers has an interesting note on the Babul forests of Berar. In his opinion there is no doubt that regulated and light grazing of cows and bullocks from the beginning in areas sown with this species is beneficial in helping the seedlings to establish themselves, by keeping down the growth of competing grasses and other weeds. The Babul seedlings appear to be protected to a great extent by their spines from injury by the cattle.

Economic.

11. Dr. Mann has published a paper, on the cultivation of the rubber tree, *Hevea brasiliensis*, in Cachar,[2] on an approved system of tapping for rubber[3]

[1] Indian Forester, Vol. xxxiii, p. 265.

[2] Agricultural Journal of India, Vol. ii, Part iii, p. 273.

[3] Agricultural Journal of India, Vol. ii, Part iii, p. 277.

and on the general question of the commercial prospects of the rubber of *Ficus elastica*.[1]

In the South Thana Division of Bombay, cultivation of *Hevea brasiliensis*, *Castilloa elastica*, *Ficus elastica* and *Manihot glaziovii* was started on a small scale with fairly satisfactory results.

A considerable number of specimens was collected by Forest Officers during the year for the Reporter on Economic Products.

Miscellaneous.

12. Mr. Hill has a paper on the acclimatization of *Swietenia Mahagoni* in India,[2] Mr. C. E. C. Fischer has two papers, one on the patches of evergreen forests known as "sholas" in North Coimbatore,[3] and the other on host plants of *Loranthaceæ*.[4] Mr. F. H. Todd has an interesting paper on the forests of *Pterocarpus dalbergioides* in the Andamans,[5] and Mr. Ellis on the flowering of *Cephalostachyum pergracile*.[6]

FOREST PRODUCTS

BY

R. S. TROUP, F.C.H.,
Imperial Forest Economist.

Forest Research Institute.—Since the inauguration of the Imperial Forest Research Institute at Dehra Dun a commencement has been made with several important investigations connected with Forest Economic Products, the results of some of which, it is hoped, will be published shortly. The chief of these investigations deal with the utilization of the less well-known Indian timbers, the suitability of others for special industries such as the manufacture of matches, tea-boxes and lead-pencils, while the demands of the market for railway-sleepers and paving-blocks is receiving attention. The seasoning qualities of different woods are being studied, particularly as regards the percentage of contained moisture, and among minor forest

1 Agricultural Journal of India, Vol. i, Part iv, p. 390.
2 Indian Forester, Vol. xxxiii, p. 308.
3 Indian Forester, Vol. xxxii, p. 481.
4 Indian Forester, Vol. xxxiii, p. 353.
5 Indian Forester, Vol. xxxii, p. 581.
6 Indian Forester, Vol. xxxiii, p. 323.

products the most practical methods of cultivating lac, and the present market conditions of cutch ; oil seeds of forest trees and other products are receiving attention. Experimental cultivation of *Podophyllum Emodi* is also being carried out.

Strength Tests of Indian Timbers.—Much useful work on the testing of Indian timbers has been carried out during the past few years by Professor Everett of the Sibpur Engineering College with wood specimens supplied by the Forest Department. The results are embodied in Mr. Everett's "Memorandum on Mechanical Tests of some Indian Timbers" (Forest Bulletin No. 6, 1906), and show figures for shearing, crushing and bending tests, as well as for stiffness from bending, in respect of 398 wood specimens comprising 38 different species of Indian trees. From a comparison of these results with those published by Professor Unwin in regard to 87 wood specimens from various British Colonies, and those of tests made on 32 American timbers under the direction of the United States Government, it appears that Indian timbers hold the first place as regards shearing and bending strength and are not excelled in stiffness.

Effect on Timber of the Tapping for Resin.—Further tests of the relative strength of tapped and untapped pine trees (*Pinus longifolia*) were carried out during the year, the results of which confirm those of the previous year and agree with those made in America, namely, that tapping does not weaken but if anything strengthens the timber, while as to durability and immunity from insect attack the removal of resin makes little or no difference. The matter is of some importance in India where *Pinus longifolia* timber is much used by right-holders in the hills, and may later on form a considerable article of export.

Tapping Pine Trees on the Skew and on the Straight.—An interesting experiment, instituted by Mr. W. H. Lovegrove of the Forest Department in the *Pinus longifolia* forests of the Naini Tal Forest Division, has been in progress since 1904. One hundred selected trees were tapped by vertical blazes, and the same number of similarly situated trees by blazes running at an angle of 15 degrees. The result of three years' tapping shows that the latter produced 15·7 per cent. more crude resin.

Lac.—Investigations into the life history of the lac insect and the best methods of propagating and harvesting lac have been in progress

during the year, particularly in the Southern Circle of the Central Provinces. In the Bhandara Division, where the lac is sown on *Butea frondosa*, *Zizyphus Jujuba* and *Z. Xylopyrus*, it has been noticed that the insect is most successfully cultivated on the first named species, which shows a preference for black cotton soils, also that the grazing of goats is beneficial to the spread of this tree whose foliage they avoid while enjoying that of its associates. It has also been noticed that light rainfall during the time when the insects swarm would appear to be favourable to their establishing themselves successfully.

Tans.—A detailed report has been received on the tanning properties of extracts of the barks of *Terminalia tomentosa*, *Shorea robusta* and *Rhizophora mucronata* (Mangrove) prepared by Professor Dunstan's decolorising process by the Forest Department at Rangoon Tannin Factory. The first trials of this process may be considered satisfactory, although sodium bisulphite was used instead of the metabisulphite recommended, and afford hope that the extracts of *Shorea robusta* and *Terminalia tomentosa* may later on find a ready sale in India, provided that bark is used from trees which are not too old, that the decolorising process suggested is employed, and that great care is taken in the evaporation of the extract. As regards the extract of *Rhizophora mucronata*, there is no reason why this extract should not find a place in the home markets when it becomes better known. The Tannin Extract Factory in Rangoon is now closed as it is considered that enough has been done to prove the practicability of the manufacture on a commercial basis of this commodity in India.

Samples of tannin extract prepared by the District Forest Officer of South Canara from the wood of *Xylia dolabriformis* were found to contain 71·2 per cent. and 77·5 per cent. of tannin. The amount of tannin present is satisfactory, but the amount of colouring matter in the extract greatly reduces its value.

Experiments made in England with the "kino" of *Pterocarpus Marsupium*, prepared by the Madras Forest Department, showed that although this substance, in conjunction with sodium metabisulphite, possesses good tanning properties, its cost is too high as compared with other equally suitable tanning agents.

Rubber.—Further samples of Assam rubber (*Ficus elastica*) sent

to the Reporter on Economic Products have been analysed, with the following results:—

	Moisture.	Caoutchouc.	Resins.	Ash, etc.
Poona . . .	13·20	76·00	9·25	1·55
Ganjam . . .	3·7	85·20	7·8	3·3
Kulsi (Assam) . .	0·7	78·00	19·0	2·79
Ditto . .	2·1	80·00	16·00	3·84
Charduar (Assam) .	·09	76·67	19·2	4·10

The high percentage of resin from the Assam specimens would appear to show either that the trees have not yet reached a sufficient age for producing the best rubber or that some unknown factor influences the quality of rubber from the Assam plantations.

The latices of some other species of *Ficus* were submitted to examination, but none were found to yield rubber in any quantity, the amount of rubber varying from 5 per cent. in *F. glomerata* to 31 per cent. in *F. tomentosa*.

Samples of the rubber of *Parameria glandulifera* from Burma and the Andamans were found to contain 91·8 and 91·6 per cent. of caoutchouc, respectively; both samples were reported to be good rubbers. Owing to the difficulty and therefore high cost of collection, however, it is doubtful if this rubber will ever reach much economic importance.

A sample of Para sheet rubber (*Hevea brasiliensis*) from the Mergui plantation was reported by Professor Dunstan to be equal in value to the best Straits rubber.

Though the Research Institute will still continue to receive and report on samples of rubber, it should be noted that this industry, which in its initial stages received so much assistance from the Department, is now established in India, and that the Government plantations are now offered for sale or lease, so that further experiments with regard to the cultivation of known species are not considered necessary.

Botanical and other specimens.—Numbers of botanical specimens, as well as timbers and miscellaneous forest products, were collected by the Forest Department and supplied to the Reporter on Economic Products, the Director of the Botanical Survey of India, the Industrial Exhibition, Calcutta, the Government Central Museum, Madras, and other Institutions, including Harvard University, America. Specimens of certain grasses were supplied to the Economic Botanist, Bombay.

Seeds.—The seeds of many Indian species were, as in former years, supplied to British Colonies and Foreign countries for experimental

propagation. Seeds of several Himalayan species, as well as *Dalbergia Sissoo* and *Ficus infectoria*, were sent to the Forest Department, Orange River Colony. The Transvaal was supplied with deodar seed. Seed of *Ficus elastica* from Eastern Bengal and Assam was sent to various firms, officials and individuals.

List of publications.

EARDLEY-WILMOT, S.	Notes on the Influence of Forests on the Storage and Regulation of the Water-Supply.—Forest Bulletin No. 9.
HOOPER, D.	Acacia Catechu.—Composition and trade forms of Indian Cutch.—Agricultural Ledger No. 3, 1906.
HOOPER, D.	Costus speciosus.—Uses and value of the root as a food-stuff.
SURENDRA NATH DEY	Cochlospermum Gossypium.—A short account of the seeds and oil.
EVERETT, W. H.	Memorandum on Mechanical Tests of some Indian Timbers.—Forest Bulletin No. 6.
COVENTRY, E. M.	Ficus elastica.—Its Natural Growth and Artificial Propagation. Forest Bulletin No 4.
BALD, C.	The Cultivation of Ficus elastica.
TROUP, R. S.	Indian Forest Utilization.

THE PROGRESS OF INDIAN ZOOLOGY, 1907

BY

N. ANNANDALE, B.A., D.Sc., C.M.Z.S.,

Superintendent, Natural History Section, Indian Museum.

Owing to causes into which it is unnecessary to enter, it has been impossible to carry the present report beyond the end of August, but next year's report will commence from that date. In my general survey I have not dealt with questions affecting Agricultural or Forest Entomology or Veterinary Parasitology, as supplementary reports are submitted by the officers directly concerned with the study of these branches of applied Zoology.

I.—The work of the Natural History Section, Indian Museum.

Survey of the Invertebrate Fauna of Stagnant water.—Additional collections of microscopic freshwater animals have been made in Calcutta, Eastern Bengal, the United Provinces and the Simla Hill States by the Superintendent and the Museum Collector, and have been sent for determination to Prof. von Daday of Buda Pesth, while a large number of specimens of aquatic and semi-aquatic insects have been obtained from the same districts. The aquatic Hemiptera have been sent to Mr. W. L. Distant for description in a supplement to his volumes on the order in the "Fauna of British India," the Chironomidæ (Midges) to the Abbé Keiffer in Germany, and the Neuroptera to Prof. Needham in the United States, while arrangements are being made regarding the working out of the aquatic beetles in France. The Anophelinæ among the mosquitoes have been identified in the Museum, while the Culicinæ will be identified in England by Mr. Theobald.

The work has not, however, been confined to the collection of specimens and their transmission abroad for identification, for investigations have been made into various obscure points in the structure and biology of the freshwater sponges (of which several new species have also been described), such as the process of budding, the nature of the inhalent pores, commensalism and the production of gemmules.

Even more important than the fauna of freshwater ponds is that of the brackish pools in the Ganges delta, especially in the neighbourhood of Port Canning. Large collections have been made in such ponds, and I hope shortly, with the aid of the Rev. T. R. R. Stebbing, Dr. J. G. de Man, Mr. E. A. Smith, Mr. W. L. Distant, Col. Godwin Austen, M Régimbart and Prof. von Daday, to publish a complete fauna. It has been possible, thanks to the work done nearly forty years ago by the late Dr. F. Stoliczka, of the Geological Survey of India, to trace a very rapid and extraordinary change in the structure and habits of a sea anemone (*Metridium schillerianum*) which occurs in certain brackish ponds of recent origin at Port Canning, while the other elements in the fauna to which this remarkable species belongs have proved of great biological interest.

Survey of the Himalayan Fauna.—Special attention has been paid during the year to the lizards, Hemiptera and two-winged flies of

the Himalayas, collections having been made by the Museum Collector in Nepal and the Darjiling district and by the Superintendent in Kumaon and the Simla Hill States. The less obscure Hemiptera obtained have been identified by the Special Entomological Assistant; many of the Diptera by Mr. E. Brunetti, who has been employed by the Trustees of the Museum to arrange the collection of Diptera; and the lizards by the Superintendent.

As regards the lizards, two new species have been discovered and, what is more important, the distribution of the common forms has been considerably elucidated. It is interesting to note, as illustrating how little is known of the Indian fauna, that the late Dr. Blanford, the greatest authority on the distribution of the Indian vertebrates, was ignorant that the genus *Calotes* occurred in the Himalayas, although the common "bloodsucker" (*C. versicolor*), which is extremely common all over the plains of India, is almost as common in Darjiling and Kumaon as it is in Calcutta.

Many of the more conspicuous Himalayan Hemiptera collected during the year and already identified are proved to have a much more extensive range to the west than was previously known, evidently forming part of a Malayo-Himalayan fauna widely distributed in the Malay Peninsula, Burma and the Himalayas.

The collections of Himalayan Diptera, on the other hand, show that Palæarctic representatives of this order occur not only in the western but also in the eastern districts at comparatively low elevations. This is particularly noticeable as regards the Syrphidæ (hover flies), many of which are identical with common British species.

Survey of the Insects of Calcutta.—A collection of the insects of Calcutta and the immediate neighbourhood is in progress under the superintendence of the Special Entomological Assistant, particular attention being paid to the Diptera and to those groups on which volumes in the "Fauna of British India" are being prepared in London.

The regularity with which the species of many of the groups reappear week after week among the specimens brought to the Museum shows that in some groups (notably the Jassidæ and Fulgoridæ) the collection is already approaching completion. It is hoped that it may be possible before very long to begin the publication of an insect

fauna of Calcutta, giving the dates of occurrence and other particulars as regards each species.

Survey of the Rats of India.—Important pioneer work on this survey has been done by the publication of Dr. W. C. Hossack's memoir on the rats of Calcutta, and also by the issue of a smaller pamphlet by the same author in which directions are given as to the collection and preservation of specimens of the Muridæ. Rats are already beginning to arrive at the Museum from different parts of India, the Government of India having distributed Dr. Hossack's pamphlet with a strong recommendation that specimens should be collected and forwarded to headquarters. The chief points in Dr. Hossack's work have recently been confirmed by the independent investigations of Captain Gourlay, of the Indian Medical Service, in Dacca; but Captain Gourlay has shown that *Mus decumanus*, nowadays the common rat of Europe, either does not occur or is extremely rare in the interior of Eastern Bengal, although it is by no means rare in Calcutta and other Indian ports. Work on similar lines in other parts of India is necessary, if we are to gain an exact knowledge of the distribution of the different species, and can be undertaken by any man with a scientific training and an instinct for accuracy; but as more technical knowledge is needed for the identification of obscure forms of Muridæ, the Trustees of the Indian Museum have authorized the Superintendent while on leave in Europe to obtain the services of a competent mammalologist as temporary assistant. If the appointment of such a man can be effected, it is believed that a great deal of the confusion at present existing as regards the taxonomy of the smaller Indian mammals will be swept away, and probably the number of species said to exist will be considerably reduced.

The survey work of the Museum has been greatly facilitated by the assistance given in Nepal by the Resident, Major J. Manners Smith, V.C., C.I.E., and in the United Provinces by the Lieutenant-Governor, Sir John Hewett, K.C.I.E. The appointment of a regular collector, for which Government have given sanction during the year, has also made work very much easier, besides greatly increasing the reference collections.

Survey of the Fauna of the Indian Seas.—The zoological work of the Marine Survey of India has always been so intimately connected with the Museum that it may be considered under the same general heading. The Surgeon Naturalist on the Survey Ship "Investigator"

has for many years spent the monsoon season in Calcutta arranging and working out the collections dredged under his direction. During the present year the collections as yet received at the Museum have been smaller than usual, chiefly owing to the fact that the "Investigator" was practically put at the disposal of the zoologists appointed to investigate the Mergui pearl banks; but a complete set of the specimens obtained by these gentlemen will ultimately be deposited in the Museum. Last year's hauls, moreover, were very rich, among the most interesting specimens obtained being several of the gigantic Isopod *Bathynomus giganteus*, including an adult female with eggs, and a fine series of the bilaterally symmetrical hydroid *Branchiocerianthus*, which had not previously been obtained from Indian seas. Captain R. E. Lloyd, I.M.S., Surgeon Naturalist, who is at present attached to the Museum, is engaged on an account of the anatomy of the Isopod, and also in describing many new and interesting species of fish and crustaceans.

Year by year the zoological work of the Marine Survey of India becomes more and more important as our knowledge of the deep-sea fauna of the world increases and it, therefore, becomes possible to make a more accurate comparison between the fauna of the abysses of the Indian Ocean and that of other seas. The investigations of the Surgeon Naturalists of the "Investigator" and of those who have described their collections (especially of Lieutenant-Colonel A. W. Alcock, the retiring Superintendent of the Museum) have given Indian Zoology a unique position in the world of science. The importance, therefore, of continuing and even extending such researches cannot be overestimated, and it is to be hoped that the construction of a more modern vessel, which is to replace the old "Investigator" before this year is finished, will give increased facilities for zoological work.

Publications of the Indian Museum.—With the increase of the collections in the Museum and the increased assistance it has been found possible to obtain from foreign specialists, it has become necessary that the Museum should possess a medium for the publication of the results obtained. It has, therefore, been decided to issue a quarterly journal under the title of "Records of the Indian Museum," and to continue the issue of more extensive monographs on the Indian fauna in a serial form. Two parts of the first volume of the "Records" have already been published and two more will be issued shortly, completing the first volume.

P. 89. Reference to the teaching of Medical Zoology is omitted from this report as not being within the province of the Board.

II.—Zoological work of the Indian Colleges and Scientific Societies.

The only zoological work done during the year in any college in India, has been, with the exception of a few incidental observations on mosquitoes and parasites, an investigation into the anatomy of fresh-water Oligochætes by Major J. Stephenson, I.M.S., Professor of Biology, Government College, Lahore.

The function of scientific societies is in the main to publish the results of work done in the laboratories of scientific institutions and to encourage the undertaking of such work. In India there are two societies that publish zoological papers, namely, the Asiatic Society of Bengal and the Bombay Natural History Society. The former has been the mother of almost every scientific publication in India, its latest offspring being the "Records of the Indian Museum," which must in fairness be ascribed to their proper parentage. It would be out of place in the present report to enter into a detailed account of what the Society has done for zoology in India; but the number of zoological papers recently published in its "Proceedings" and "Memoirs" is sufficient guarantee that it is not, as some have thought, purely a philological body.

The "Journal of the Bombay Natural History Society" is practically restricted to Botany and Zoology, and has shown no falling-off during the year in the number of its papers and the excellency of its illustrations. It is no reflection on the valuable work done by this Society to say that it deals mainly with the groups of animals that are most popular among amateurs and have, therefore, been most studied in the past. The appointment of a trained zoologist to be in charge of the Society's Museum (which appointment has recently been made) should, however, prove an important event in the history of zoology in western India.

III.—Medical Zoology.

The facts that militate against zoological research in the colleges are as antagonistic to the study of medical zoology. Medical men have often had special zoological training before coming to India. In India they have, with rare exceptions, no opportunity of keeping in touch with zoological literature, and no central authority to whom they can refer for advice and assistance. The staff of the Indian Museum has never chanced to include an expert on Protozoa or Diptera, and it is these two groups that have chiefly attracted students of tropical disease,

although there is every probability that others will ultimately prove important from a medical or sanitary point of view. Without a large increase in the staff of the Museum it is improbable that the services of such specialists will be available. The staff at present consists of a single officer, who is fortunate in having secured the temporary assistance of a Dipterist.

Notwithstanding the difficulties under which they labour, zoological work bearing directly or indirectly on medical studies has recently been done by several members of the Medical Service, and has been published in the "Scientific Memoirs of the Officers of the Medical and Sanitary Departments" and in the form of notes in various medical journals.

IV.—Zoological work on Fisheries.

The Government of Bengal have published a report on the fisheries of the province by Mr. K. G. Gupta, I.C.S. Beyond dealing in a general way with the distribution and habits of a few common species, the report wisely ignores the biological problems involved, for it is stated that a trained zoologist will be appointed to assist Mr. Gupta's successor, who will apparently be another member of the Indian Civil Service. Investigations on the Madras fisheries of a statistical and economic nature have been continued under a retired member of the same service, but nothing of biological interest has as yet been published. A collection of marketable fishes was made at Akyab in February last by an agent of the Reporter on Economic Products, and has been worked out in the Indian Museum by Captain Lloyd. Including "whitebait," it comprised over seventy species, of which one has proved new to science (*Lactarius burmanicus*) although apparently not uncommon, while several were of considerable zoological interest. It is hoped that it may be possible to make similar collections during next year at different fishing centres, and arrangements have already been made as regards specimens from the Chilka Lake in Orissa.

During the early part of the year, the Government of India, at the request of the Government of Burma, appointed two zoologists, Mr. Rudmose Brown, late Naturalist to the Scottish Antarctic Expedition, and Mr. Simpson, late assistant to the Professor of Zoology at Aberdeen, to investigate the pearl banks of Mergui. Their time on the Burmese coast was extremely short, and their report has not yet been published. Mr. Brown has, however, published a short general paper

in the Scottish Geographical Journal. The collection, of which a complete set will be deposited in the Indian Museum, should prove of great interest in conjunction with those made in Mergui by the late Dr. J. Anderson, which we already possess. A set of the pearl oysters (three species) collected in the Persian Gulf has been submitted for identification to the Indian Museum. Some of the shells examined are much injured by the burrows of a mussel (*Lithodomus malaccanus*), which does not appear to have been previously reported as an enemy of pearl oysters.

V.—The "Fauna of British India and Ceylon."

Three volumes on insects have recently been published in this series, two on butterflies by Lieutenant-Colonel Bingham, and one on Cerambycidæ (beetles) by Mr. Gahan. Two others are in the Press, one on the remaining families of the Homoptera by Mr. W. L. Distant and one on Phytophagous beetles by Mr. Martin Jacoby, others on insects being in various stages of progress.

VI.—Work on Indian Zoology in European and American Colleges and Museums.

The greater part of the work done abroad during the year on Indian collections has been done on specimens sent out from the Indian Museum. In the British Museum Messrs. G. A. Boulenger and Tate Regan have worked at Amphibia and fish from this source; in the Hamburg Museum Dr. Michaelsen has devoted a considerable part of his time to a large collection of Indian earthworms, while Dr. Kraepelin has examined freshwater Polyzoa; in the "Polytechnicum" of Buda-Pesth Prof. von Daday has been occupied by the collection of microscopic freshwater fauna already alluded to; in Paris Prof. Joubin is examining the "Investigator" Brachiopods and Prof. Blanchard the leeches; at Lyon Prof. Koehler has nearly completed his monograph on the shallow-water Holothurians of the Indian coasts; while at Aberdeen Prof. J. Arthur Thomson, who has recently described the deep-sea Alcyonarians, is doing the same for the shallow-water representatives of the group; in the Royal Scottish Museum at Edinburgh Mr. Ritchie has commenced work on the Museum collection of hydroids; in the University of Liverpool Miss L. Thornely has concluded a report on the marine Polyzoa; in New York State Prof.

Needham has nearly finished his description of the Neuroptera; while the Orthoptera, Curculionidæ, Lamiidæ, Cetoniidæ and Dynastidæ are being named in the British Museum, in connection with the "Fauna of British India," under the superintendence of Colonel Bingham.

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Ditto, No. 14.—Notes on the skull of the genus *Aulastomatomorpha*, with descriptions of some new deep-sea fish, by R. E. Lloyd, M.B., B.Sc., Captain, I.M.S. *Ibid.*, p. 306.

Ditto, No. 15.—Second preliminary report on the deep-sea Alcyonaria collected in the Indian Ocean, by Prof. J. Arthur Thomson, M.A., and W. D. Henderson, M.A., B.Sc. *Ibid.*, p. 427.

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A third note on Earwigs (Dermaptera) in the Indian Museum, with the description of a new species, by Malcolm Burr, B.A., F.Z.S. *Ibid.*, p. 207.

Notes on Oriental Diptera, No. III, E. Brunetti. *Ibid.*, p. 211.

Notes on a collection of marketable fish from Akyab, with a description of a new species of *Lactarius*, by Captain R. E. Lloyd, B.Sc., I.M.S. *Ibid.*, p. 219.

Description of two freshwater Oligochæte worms from the Punjab, by Major J. Stephenson, I.M.S. *Ibid.*, p 233.

Notes on phosphorescence in marine animals, by Captain R. E. Lloyd, B.Sc., I.M.S. *Ibid.*, p. 257.

Notes on the rats of Dacca, Eastern Bengal, by Captain C. A. Gourlay, I.M.S. *Ibid.*, p. 263.

Notes on freshwater sponges, Nos. I—V, by N. Annandale, B.A., D.Sc. *Ibid.*, p. 267.

In the Annales de la Soc. Entomologique de Belgique.

Malacodermes du sud de l'Inde. Par J. Bourgeois.

Scientific Memoirs by officers of the Medical and Sanitary Departments of the Government of India, New Series, 1907.

No. 25.—On the importance of larval characters in the classification of Mosquitoes, by Captain S. R. Christophers, M.B., I.M.S.

No. 26.—*Leucocytozoon canis*, by Captain S. R. Christophers, M.B., I.M.S.

No. 27.—Preliminary report of the development of the Leishman-Donovan body in the bed bug, by Captain W. S. Patton, M.B., I.M.S.

No. 28.—The sexual cycle of *Leucocytozoon canis* in the tick, by Captain S. R. Christophers, M.B., I.M.S.

Report to the Government of Ceylon.

Report on the Pearl Oyster Fisheries of the Gulf of Manaar and Marine Biology of Ceylon, Part V, by W. A. Herdman, D. Sc., F.R.S., P.L.S., 1906.

Occasional Publication of the Indian Museum.

The Deep-Sea Alcyonarians from the Indian Ocean, by J. Arthur Thomson, M.A., B.Sc., 1906.

Aids to the identification of rats connected with plague in India, by W. C. Hossack, M.D.

Besides the papers mentioned in the above list many shorter notes, descriptions of single species, etc., have been published in the Proceedings of the Asiatic Society of Bengal, the Journal of the Bombay Natural History Society and the Records of the Indian Museum.

AGRICULTURAL ENTOMOLOGY

BY

H. MAXWELL-LEFROY, M.A., F.E.S., F.Z.S.,

Imperial Entomologist.

The study of the insect pests of crops was continued by the Imperial Entomologist, his staff and the Assistants in Provincial Agricultural Departments. The detailed study of the more important insect pests was continued in the insectary, and on the experimental farm at Pusa as well as in the field, and coloured plates representing these insects in all stages were prepared. The success attending the re-introduction of the cotton bollworm-parasite to the Punjab led to the adoption of this measure in Sind. The occurrence of swarms of locusts in the Punjab necessitated a campaign against this pest, carried on by the Punjab Agricultural Department with assistance from the Imperial Entomologist's staff. The measures adopted were those previously in use, experiment having shown that other suggested measures were less efficient, and, since the so-called Locust Fungus has been proved ineffectual, it is believed that these measures are the most satisfactory ; further experiment will not be continued.

The extension of the jute experimental plots to new tracts has necessitated special attention being paid to the pests of this crop, especially on small experimental areas, but these pests will probably be of slight importance in localities where any considerable area of jute is planted.

Greater attention is being paid to the insects injurious to indigo in Behar, the introduction of the Java-Natal plant and the consequent modification of methods of cultivation having altered the conditions and brought new pests into prominence.

The prevalence of the introduced potato moth in Bombay and of the very important Groundnut Leaf Miner in Madras have been enquired into. Insect pests of cane, and of castor, as well as termites, have also been specially investigated.

A considerable advance has been made in the work of Provincial Assistants, notably in Madras where the common pests of staple crops are being for the first time systematically investigated.

The publication of "Indian Insect Pests" has drawn general attention to the injuries caused by insects and, judging from the inquiries received, has had a distinct effect in bringing home to the more educated agricultural community the salient facts regarding the lives of insects. This is the real benefit derived from the publication of this work. The publication of articles in the Agricultural Journal, with good coloured illustrations, has also had its effect. The increased number of enquiries received has made it possible to diffuse information more widely, and the work of Provincial Assistants is also making itself felt.

The enquiry into insecticides non-poisonous to cattle was continued and reached the stage of field trial. The experimental cultivation of the eri silk worm (*Attacus ricini*) was taken up at Pusa to determine primarily whether by any simple means the worms can be made to thrive during the hot weather. An excellent quality of silk was obtained and this work will be continued on a small scale until the problem is settled. The cultivation of lac on bair trees (*Zizyphus jujuba*) was also commenced at Pusa, partly as an educative object-lesson for students, partly to determine how far the very small existing cultivation of lac in Behar can be improved. A small experimental cultivation will be maintained, existing methods will be improved if possible and a tentative extension of lac outside Pusa is being made. The increase in the routine work, and especially in the number of enquiries received from all parts of India, has made it necessary to temporarily put aside some researches mentioned in last year's report.

Mr. C. B. Antram, Entomologist to the Indian Tea Association, has continued his work on insects injurious to tea. Further study was made of the Looper Caterpillar (*Bision suppressaria*), and Sandwich Caterpillar (*Agriophora rhombota*, Meyr.). An account of the four "Bark-eating Borers of Tea" was prepared, dealing with insects whose life histories were previously unknown. Further attention is being paid to Mosquito Blight and to mound-building White Ants.

Progress was made in the enquiry into biting flies, mentioned in last year's report. A number of biting flies was found and studied; the dreaded Tse-Tse fly of Africa was not found and this confirms the view that it does not occur in India. The collections made are

being worked out and this work will now pass into the hands of the Second Imperial Entomologist, Mr. F. M. Howlett.

Progress has been made with the Insect Survey of India carried on in co-operation with the Indian Museum, Calcutta. Further collections were sent to specialists in connection with the Fauna of India volumes and some were received back. The whole named collection is maintained in a properly arranged condition and so catalogued on cards that any group or species can be readily found.

The text of a volume on the Insects of India, with reference to the plains or cultivated areas only, was prepared as well as the necessary illustrations ; it is proposed to publish this in due course.

List of Publications.

MAXWELL-LEFROY, H. . Insect Pests of Jute, Agri. Journ. of India, Vol. II, No. 1.

MAXWELL-LEFROY, H. . Surface Caterpillars, Agri. Journ. of India, Vol. II, No. 2.

MAXWELL-LEFROY, H. . Locusts in India, Agri. Journ. of India, Vol. II, No. 3.

MAXWELL-LEFROY, H. . Practical Remedies for Insect Pests, Agri. Journ. of India, Vol. II, No. 4.

MAXWELL-LEFROY, H. . The Biting Flies of India, Occasional Bull. No. 7 of 1907.

WARBURTON, C. . . The Ticks infesting Domesticated Animals in India, Occasional Bull. No. 6 of 1907.

RENOUF, W. . . . Note on the Cotton failure on account of bollworm in the Central and South-west Punjab in 1905, and on the results of the measures taken to prevent a recurrence in 1906, Dept. of Agri., Punjab, Bull. No. 1 of 1907.

MAXWELL-LEFROY, H. . The more important Insects injurious to Indian Agriculture, Memoirs of Agri. Dept. in India, Entomo. Series, Vol. I, No. 2.

MAXWELL-LEFROY, H., AND C. C. GHOSH.	Indian Surface Caterpillars of the Genus *Agrotis*, Memoirs of Agri. Dept. in India, Entomo. Series, Vol. I, No. 3.
MANN, H. H. . . .	Individual and Seasonal variations in *Helopeltis theivora*, Waterhouse, with description of a new species of *Helopeltis*, Memoirs of Agri. Dept. in India, Entomo. Series, Vol. I, No. 4.
GREEN, E. E., AND MANN, H. H.	The *Coccidæ* attacking the Tea plant in India and Ceylon, Memoirs of Agri. Dept. in India, Entomo. Series, Vol. I, No. 5.
ANTRAM, C. B. . . .	A pamphlet on the "Bark-eating Borers of Tea," Indian Tea Assoc. Scientific Series, 1907 (in the Press).
MAXWELL-LEFROY, H. .	Insects injurious to books and papers.

FOREST ENTOMOLOGY

BY

E. P. STEBBING, F.L.S., F.Z.S., F.E.S.,
Imperial Forest Zoologist.

General.

The most important investigations of the year in Forest Entomology, both economically and scientifically, resulted from a visit paid by the Imperial Forest Zoologist to the Assam Sal Forests from March to May One of the chief objects of the visit was a study of the defoliators of the sal belt of this region and some important additions to the life histories of these pests were made, although the season was unfavourable for the prosecution of this study. The investigations already carried out into the bark and wood-borers infesting the sal belt of the Terai and Siwalik areas of the United Provinces and into those of the Central Provinces and Chota Nagpur tracts in which this tree flourishes led to the conclusion that it was probable that the

Assam Sal Forests would be found to contain pests similar to the *Hoplocerambyx spinicornis*, or Singhbhum longicorn borer, which commits such havoc in the Central Provinces and Chota Nagpur sal areas, and to the scolytid bark-borer *Sphærotrypes Siwalikensis*, Steb., of the Siwalik and neighbouring Terai sal areas of the United Provinces and the investigations in the Goalpara Sal Forests were rich in results of a high economic importance. *Hoplocerambyx spinicornis* proves to be a most serious pest in the Assam Sal belt where it is accompanied by a species of *Sphærotrypes* which, whilst differing specifically from its confrère of the United Provinces, has very similar habits.

In addition to these two, some forty-five pests of the sal including some insects predaceous and parasitic upon these pests were studied, the life histories of some being ascertained, from a practical working point of view, in a sufficiently complete manner. Insects infesting and ruining the seed, and thus retarding or stopping the regeneration of the species, were also studied.

In the autumn of the year a tour was made in the Jaunsar and neighbouring Tehri-Garhwal areas of the United Provinces, the principal object in view being the study of pests infesting the *Pinus longifolia* forests. A serious infestation by a weevil, specimens of which were forwarded during the year by Mr. Milward from the Almora Chir (*P. longifolia*) Areas, appeared to require immediate enquiry and this was carried out in conjunction with others connected with bark and wood-boring pests of this conifer. Enquiries were also prosecuted in connection with the presence or otherwise of autumn generations of the scolytid pests infesting the Deodar, Silver fir, Spruce and Blue pine.

The Chief Economic Results of the Year.

(a) By the Imperial Forest Zoologist.

The Assam Sal Pests.—

Hoplocerambyx spinicornis (the Singhbhum Sal borer) :—

The discovery that this longicorn beetle, previously well-known as a pest in the sal belt of the Central Provinces and Chota Nagpur, forms perhaps one of the most dangerous insect enemies in the sal belt of Eastern Bengal and Assam is of serious importance. With the

help of Mr. Perrée and one of his Range officers, Ram Nath Mukerjee, the life history of this insect in Assam, which varies in important particulars from that in Bengal, was worked out in such detail as to make it possible to indicate certain steps which it will be necessary to follow to prevent the insect acquiring a mastery over the sal areas.

Sphærotryps assamensis n. sp.—This bark-feeding Scolytid pest is by itself capable of killing living sal trees when present in sufficient numbers. As it would appear to pass through five generations in the year its appearance in an area must always be looked upon as a possible serious danger to the forest. When present in company with *H. Spinicornis*, as is the case in the Goalpara sal areas, the damage these two pests are able single handed to commit is gravely aggravated.

Other Assam Sal Pests.—Other species of longicorn beetles infesting the sal studied were *Dialages pauper*, *Caloclytus sp.* prox. *signaticollis*, *Thysia Wallichii* and *Cerambyx sp.* Amongst *Scolytidæ* bark and wood-borers may be mentioned species of *Phlœosinus*, *Dolurgus*, *Dryocetes*, *Tomicus*, *Acanthotomicus*, *Xyleborus*, *Platypus* and *Diapus*. Important observations were also made on the life histories of the defoliators *Clania variegata*, *Suana sp.* and species of *Dasychira* and *Lymantria*.

The Sal Seed destroyers.—The larvæ of three minute moths, species of *Conogethes*, *Laspeyresia* and *Cacœcia* and the grubs of a twig Scolytid beetle, probably a species of *Xyleborus*, feed inside the sal seed, entirely hollowing out the embryo and thus destroying the natural reproduction of the forest. Sixty to seventy per cent. of the sal seed examined in the Kochugaon Forests of the Goalpara Division in May 1906 was found to be infested by the grubs of these pests.

Predaceous and Parasitic Insects.—Notes on some important species of *Ichneumon*, *Chalcis*, *Bothrides*, *Niponius*, *Thanasimus* and *Platysoma*, insects parasitic and predaceous upon the Assam Sal pests, were also recorded.

Charduar Rubber Plantation Pests.—A visit was paid to this plantation which is situated in the Darrang Division in Assam, in March 1906, during which some observations were recorded on the life history of the rubber defoliating pest *Gunda sikkima* and notes recorded on a number of other pests of the *F. elastica*.

Pinus Longifolia Pests.

Cryptorrhynchus sp.—At the beginning of September Mr. R. C. Milward forwarded some dying *P. longifolia* saplings from a plantation in Almora. These were found to be infested by a species of Cryptorrhynchid weevil, the bast layer of the trees being riddled by the grubs of the beetle. Investigations carried out in Jaunsar and Tehri-Garhwal in October and November of the same year showed that this pest attacks large full grown trees as well as saplings, and that it infests green standing trees.

Tomicus and Polygraphus Bark-borers.—It was a point of considerable interest to find that *Pinus longifolia* is attacked by species of *Tomicus* and *Polygraphus* bark-borers entirely different from those infesting the *P. excelsa* and Spruce, trees living at a higher elevation in the conifer zone than *P. longifolia*. Both these important pests require considerable further study.

The Scolytid wood-borers.—Forest Officers and Tea Planters have often complained that the wood of this tree is perforated by 'shot-borers' which have been considered to be identical with the 'ghoon' or 'shot-borers' of the bamboo. Investigations into this attack has brought to light some remarkable facts and have proved that the originator of the holes is a species of *Platypus* (Fam. *Scolytidæ* or *Platypodæ*) totally distinct from the bamboo shot-borers. This insect drills holes down into the timber to lay its eggs, and attacks freshly felled trees and standing green or sickly trees.

Other Himalayan Coniferous Pests.—Considerable progress was made in the investigations into the autumn life histories of Scolytid pests of the deodar, spruce, silver fir and blue pine, but the observations carried out still necessitate further work on the life histories to enable practical means of combating the attacks and of preventing an increase in the numbers of these pests in the valuable Himalayan Forests.

The Chermes abietis-piceæ of the Spruce and Silver fir.—It is believed that the search instituted for the winter egg and stem female of this important and interesting insect has been successful.

The Sphærotrypes bark-borer in the Siwalik and neighbouring Terai Sal areas.—This insect was alluded to in the last report. It is still considered that the presence of this pest in unusual numbers in this sal areas is a source of considerable danger to the forests owing

to the sickly state of numbers of the trees, a legacy of the severe frosts of February 1905.

(b) By Other Departmental Observers.

Studies on the Assam Sal Pests.—During the visit of the Imperial Forest Zoologist to Goalpara and after his departure independent personal investigations were carried on in the life histories of Goalpara Sal Pests by the Divisional Officer, Mr. W. F. Perrée, and Extra-Assistant Conservator Ram Nath Mukerjee. The very considerable progress these investigations have reached must be in large measure attributed to the great assistance freely afforded by these officers.

The Cryptorrhynchus weevil in the Almora Pinus Longifolia area:—The discovery of this insect by Mr. R. C. Milward, Deputy Conservator of Forests, Naini Tal Division, and Ranger B. D. Kalia in the Kalimat Plantation near Almora has already been alluded to. The observations made by these officers are of valued importance.

Lymantria semicincta in the Balaghat Sal Forests.—Mr. A. St. V. Beechey made some interesting observations on the life history of a sal-defoliating caterpillar which was subsequently identified as *Lymantria semicincta*. The defoliation took place in April. The attack in question was apparently greatly reduced by a parasitic Tachinid fly resembling a species of *Mascicera*.

Albizzia Lebbek Seed attacked by Caryoborus sp.—The Divisional Officer, Nasik, Bombay Presidency, reported that Albizzia Lebbek seed in his division was infested by a beetle which was identified as *Caryoborus* sp. previously reported from Bombay in this connection.

Injurious Pests in the North Coimbatore Division, Madras.—Mr. C. E. C. Fischer reported that considerable defoliation was done to *Anogeissus latifolia* in May-June about Bailur and Gairmalam, 4,000′ to 4,300′, in many places groups of trees being entirely leafless. Mr. T. N. Hearsey reported similar attacks near Lokanhalli, 2,600′, in April 1905. The defoliation was done by caterpillars of species of *Pheosia*, *P. fasciata*, *P. strigata* and *P. sikkima*. *P. strigata* only had been previously reported from the Madras Presidency.

The caterpillars of the common moth pest *Ophnisa melicerta* were also reported as defoliating this tree at Bailur.

Arbela tetraonis and Clania Crameri in Casuarina plantations at Nellore.—The bark-eating catterpillar of the moth *Arbela tetraonis* and the bag worm *Clania Crameri* were again reported as committing depredations in the Casuarina plantation of Nellore.

Acanthophorus serraticornis in Mango in Ganjam.—Some important observations on the life history of a longicorn-borer, identified as *Acanthophorus serraticornis*, infesting the mango in Ganjam, Madras, were carried out by Mr. S. Cox, Divisional Forest Officer, Ganjam, and Mr. H. T. Reilly, I.C.S., Head Assistant Collector, Chicacole, Ganjam. This insect is one of the largest known of Indian Cerambycidæ, and the discovery is made for the first time that its grubs, which have previously been reported as infesting sal wood, riddle mango trees. Serious injury is done by the insect to valuable mango orchards in this locality.

The Teak defoliators in Travancore.—The Conservator of Forests, Travancore, continued to forward to this office during the year quarterly reports detailing the areas and percentage of teak forest attacked by the teak defoliators *Hyblœa puera* and *Pyrausta damastesalis*. These reports have now been sent in for several years, and some interesting and valuable information on the subject of the periodicity and severity of the attacks of these pests will shortly be available for publication.

The teredo marine-borer in Bamboos.—Experiments were commenced during the year to test whether bamboos placed in sea and tidal waters are subject to the attacks of the teredo borer and if so in how short a period after exposure they will be tunnelled into. The experiments which were made after the close of the year with various species of bamboo have shown that whilst all species ultimately succumb to the teredo their powers of resistance vary.

Bostrichidæ infesting Engyin wood in Rangoon Depôts:—Mr. F. Wood of Messrs. Foucar & Co., of Rangoon, forwarded through Mr. S. Carr, Deputy Conservator of Forests, a beetle identified as a species of *Bostrychopsis* which was discovered tunnelling into Engyin (*Pentacme suavis*) logs in the firm's depôt. As the beetles of this family prove at times serious timber pests, the firm in question has been asked for a further report on the subject.

By other Observers.

Help afforded by authorities in combating the Quetta-borer.—The 'Quetta Borer' attack, as it is known, was fully dealt with in last year's report. A part of the treatment advocated for getting rid of the pest was to leave standing a certain number of affected 'trap' trees throughout the station, at the time the heavy fellings were being made, with the object of affording the beetles, issuing in the spring subsequent to the fellings, localities for egg-laying and thus preventing their attacking as yet unaffected healthy trees. The suggested treatment laid down, that these trap trees were to be felled and burnt in the following autumn, was undertaken and this part of the work was successfully brought to a close by the authorities. It is hoped that these operations will have reduced the numbers of the beetle to normal and thus prevent further damage being done to the avenues in the station.

The Duki Fig-tree Borer (Batocera Rubus).—Major C. A Kemball, C.I.E., Political Agent, Loralai, reported that the fig trees in the Duki garden in his agency were being attacked and killed by a borer resembling the Quetta borer. As the fig tree is planted in many of the fruit gardens in Baluchistan it was of considerable importance, in view of the operations being undertaken in Quetta, to identify this pest as early as possible. Under instructions sent to him Major Kemball, some months later, was able to forward perfect specimens of the beetle whose grubs were committing the damage. It proved to be *Batocera rubus* and thus set the fears aroused as to its identity with the Quetta borer to rest. In a note issued during the year the necessary treatment to be put in force was indicated and through the Honourable the Agent, all officers in Baluchistan were instructed to keep a watch for this pest.

Buprestid grubs in Poplar and Willow trees in Loralai, Baluchistan. – A communication was forwarded by Colonel G. F. Goot, Commanding 37th Cavalry, Loralai, to the effect that the poplars and willows in the station were being tunnelled into by grubs similar to the Quetta borer. As the latter insect has not yet been found in Loralai this communication was of interest. The specimens of grubs sent proved, however, to be *Buprestidæ*. No beetle has yet been taken.

Chief Scientific Results of the year.

The distribution of Hoplocerambyx spinicornis and Sphærotrypes in the Indian Sal belt.—Although the longicorn *H. spinicornis* had been previously reported from Assam, the discovery that it was a serious pest in the sal forests of Eastern India and the observations made on its life history are recorded for the first time in 'Some Assam Sal Insects,' a monograph compiled during the year *Sphærotrypes* has not yet been taken in the sal areas in the Central Provinces, Chota Nagpur and Ganjam, but the genus is now known in the sal belts of the United Provinces, Siwaliks and Terai and in Buxa Duars, Bhutan and Assam and it is probably the most dangerous bast-eating Scolytid of these areas.

Pinus longifolia bark and wood-borers.—The discovery of species of *Tomicus* and *Polygraphus*, bast-eating beetles, different from those infesting the *P. excelsa*, in the *Pinus longifolia* is of considerable interest in that it proves that the Himalayan conifers are probably subject to attack by a greater number of distinct species of Scolytid beetles than are their European confrères. It is also of importance to determine the chief wood-borers of this tree and it is significant, as proving the Indian economic importance of the family which is but sparsely represented and of little economic importance in Europe, that one of them should prove to be a species of *Platypus* (Fam. *Platypodæ*).

Literary Work. – Amongst purely literary work may be mentioned the 'Note on the Duki Fig-tree borer (*Batocera rubus*)'; a monograph on 'Some Assam Sal Insect Pests' containing a large amount of original investigation work including descriptions of new *Scolytidæ*; a monograph on the Lac Insect; and the series entitled 'Insect Life in India and how to study it' published in the Journal of the Bombay Natural History Society.

Co-operation of Experts.—I have to acknowledge the usual hearty co-operation of the experts at the British Museum, Paris and Berlin Museums, and my other scientific confrères working at particular branches of natural history.

List of Publications.

STEBBING, E. P. . . A note on the Duki Fig-tree borer of Baluchistan (*Batocera rubus*). Forest Bulletin No. 10 (1907).

STEBBING, E. P. . . The Phases of the moon on the period for felling bamboos—Indian Forester, xxxii, 534.

STEBBING, E. P. . . On Some Assam Sal (*Shorea robusta*) Insect Pests—Forest Bulletin No. 11 (not yet issued).

DESNEUX, J. . . The Kashmir Termite (*Termes Wroughtoni*)—Journal, Bombay Natural History Society, xvii, 293.

STEBBING, E. P. . On the life history of *Termes* (*Coptotermes*) *Gestroi*, the Hevea rubber Termite — Indian Forester, xxxiii, 6.

STEBBING, E. P. . . *Lecanium capreæ*, Linn, as a pest of Almond trees in Baluchistan—Indian Forester, xxxiii, 168.

STEBBING, E. P. . . *Icerna Ægyptiaca*, Dougl. on teak in Burma—Indian Forester, xxxiii, 222.

STEBBING, E. P. . . Insect Life in India and how to study it—Journal, Bombay Natural History Society, xvii, 424.

STEBBING, E. P. . . A Note on the Lac Insect (*Tachardia lacca*)—Indian Forest Records, i., Part i, p. 1 (not yet issued).

STEBBING, E. P. . . Departmental Notes on Insects that affect Forestry, Vol. ii.

VETERINARY SCIENCE

BY

COLONEL H. T. PEASE, C.I.E., I C.V.D.,
Inspector-General, Civil Veterinary Department.

Sero-therapy.

1. As during the last year, considerable progress was made within the official year 1906-07 at the Muktesar Laboratory. The output of different sera and other prophylactics was greatly increased. This has occupied most of the time of the staff.

2. The following table will show the material difference between the preparation and issue of different products during the past year, as compared with the previous one:—

Name of serum.	Quantity prepared.	Quantity issued.	Increased manufacture as compared with last year.	Remarks.
	Doses.	Doses.	Doses.	
Anti-Rinderpest . .	467,993	458,661	256,586	
Anti-Anthrax . . .	15,280	11,814	*Nil.**	* Demand for this serum decreased.
Hæmorrhagic Septicæmia .	88,875†	57,375	73,405	†For trial in the field.
Charbon Symptomatique .	17,869	930	17,869	
Mallein	11,276	3,583	7,869	
Tetanus Antitoxin . .	22,164‡ C. C.	...	22,164 C. C.	‡Not yet tested.

According to the statistics received in this office from the Superintendents of the Civil Veterinary Departments in India and Burma, the following table, showing numbers of outbreaks dealt with and animals injected, etc., during the past 12 months, has been compiled:—

Name of disease.	Number of outbreaks dealt with.	Number of animals injected.
Rinderpest	1,313	197,259
Anthrax	137	12,668
Hæmorrhagic Septicæmia	187	36,105

Training of Officers and Veterinary Assistants.—During the months of June to September 1906 inclusive, two officers of the Civil Veterinary Department and three of Army Veterinary Corps attended the theoretical and practical classes, each one lasting for 2 months; in

addition 49 Veterinary Assistants were trained throughout the year in different methods of inoculation and serum therapeutics.

Examination of Specimens.—Reports were made on 80 specimens submitted to the Laboratory for microscopical examination from different parts of India and Burma, with the least possible delay to the respective officers interested in the same.

Extension of the Laboratory.—It is a satisfaction to note that up to the time of writing this report, great additions have been recently made to the buildings and machinery of the Imperial Bacteriological Laboratory at Muktesar, with a view to meet the ever-increasing demand of the different products prepared at this Laboratory and also to isolate the different sheds and to minimize, as far as possible, any chance of infection or contamination of the products prepared.

For this reason separate small laboratories fully equipped with apparatus, etc., self-maintained and independent of each other, together with the necessary stables or sheds at a distance apart, have been erected for the preparation of Tetanus anti-toxin, Mallein, Charbon Symptomatique vaccines, etc.

The following work done has been recorded in the Journal of Tropical Veterinary Science or in the Annual Report:—

Dourine.—Further notes bearing on the *Trypanosoma equiperdum* with special reference to its presence in the plaques, measurements under various conditions and the immunity, if any, it confers against the *Tr. evansi* were published in the Journal of Tropical Veterinary Science, Vol. I, No. 4, p. 333.

No further experiments could be initiated in the Laboratory as the disease died out there, the horses under observation having all apparently recovered. Some investigations were made at the Punjab Laboratory into a disease simulating Dourine and caused by a filaria, a note on which was published in Vol. I, No. 4, p. 414 of the Journal of Tropical Veterinary Science.

Spirochætosis in plains and hill cattle and in fowls.—This form of disease, not previously recognised in this country, was met with during the year in cattle suffering from Rinderpest, and an account of it was published under the title of "Some forms of spirochætosis met with in animals in India" in the July number of the Journal of Tropical Veterinary Science.

Spirillosis of fowls was found to be widespread and cause considerable losses in the Punjab, the transmitting agent being *Argas persicus.*

Piroplasmosis and Trypanosomiasis.—As opportunities offered, advantage was taken of material available in the laboratories to further investigation in regard to Piroplasmosis and Trypanosomiasis in cattle, horses, camels and dogs.

A detailed report on the different species of Trypanosomata observed in Bovines in India was published in Vol. II, No. 1 of the Journal of Tropical Veterinary Science.

A note on equine biliary fever was also published in the same Journal.

Canine piroplasmosis was found to be a common affection in the Punjab, but no observations have so far been published.

With regard to Trypanosomiasis observations of the course of the disease in various animals, treatment by means of drugs, notably atoxyl, and the identity or otherwise of the Trypanosomes causing equine and cameline Surra, have been carried out. The results of treatment are not, so far, constant, and work is being continued in this direction.

It has been found that the Indian elephant was either insusceptible or only very slightly susceptible to equine Surra.

Irritable summer skin disease.—Some preliminary work has been done in this troublesome skin disease, and attention drawn to its probable parasitic nature. A note was published on the subject in the Journal of Tropical Veterinary Science, Vol. II, No. 2.

Rinderpest. It has been found that, in some cases at least, the Indian elephant is apparently not susceptible to Rinderpest.

Hæmorrhagic septicæmia.—Some further work on immunity against this disease was carried out.

A list of publications contributed during 1906-07 from the Imperial Bacteriological Laboratory.

LINGARD, A. . . Annual Report of the Imperial Bacteriological Laboratory for 1906-07.

LINGARD, A. . . Further Notes bearing on the *T. Equiperdum* with special reference to its presence in plaques, measurements under various

conditions and immunity conferred, if any, against the *T. Evansi*. Journal of Veterinary Science, Vol. I, No. 4, p. 333.

LINGARD, A. . . Different species of Trypanosomata observed in Bovines in India. Journal of Veterinary Science, Vol. II, No. 1, p. 4.

LINGARD, A., AND SCOTT FALSHAW. P. A Note on a new species of Trypanosoma discovered in the blood of an Indian bullock at Singapore. Journal of Veterinary Science, Vol. II, No. 2, p. 217.

LINGARD, A. . . Some forms of Spirochetosis met with in India. Journal of Veterinary Science, Vol. II, No. 3.

LINGARD, A. . .

A list of papers published during 1906-07 bearing on such diseases.

BALDREY, F. S. H. . Some problems in sheep diseases. Journal of Veterinary Science, Vol. I, No. 4, p. 387.

BALDREY, AND W. A. MITCHELL. A Preliminary Note on Neutral reaction in the Infected Red Cells of Protozoal diseases. Journal of Veterinary Science, Vol. II, No. 4, p. 169.

BURTON CLELAND, J. . Nodules containing Larval Nematode worms in the Intestinal Submucosa of a bullock. Journal of Veterinary Science, Vol. II, No. 1, p. 67.

JOLIFFE, C. H. H. . Some remarks on Equine Biliary Fever in India. Journal of Veterinary Science, Vol. II, No. 1, p. 51.

MESNIL, F., AND NICOLLE, M. Treatment of Trypanosomiasis with Benzidine colors. Journal of Veterinary Science, Vol. II, No. 1, p. 101.

MESNIL, F., AND ROUGET, I. Sensibility of Ruminants and Monkeys to the Trypanosoma of Dourine. Journal of Veterinary Science, Vol. II, No. 2, p. 177.

NESFIELD, V. B. . . Preliminary Note on a Parasite found in connection with "The Irritable Summer skin

disease" of horses in India. Journal of Veterinary Science, Vol. II, No. 2, p. 172.

PRICOLO ANTONIO . Further contribution to the study of Equine Piroplasmosis. Journal of Veterinary Science, Vol. II, No. 1, p. 122.

PEASE, H. T. . A disease simulating Dourine caused by Filaria. Journal of Veterinary Science, Vol. I, No. 4, p. 414.

PLACE, F. EVELYN . Intra-ocular Infection by Tetanus. Journal of Veterinary Science, Vol. I, No. 4, p. 417.

PATE, CHAS. W. . Rabies in a goat. Journal of Veterinary Science, Vol. I, No. 4, p. 419.

RODET, A., AND VALLET, G. Contribution to the study of Trypanosomiasis—Experiments with Trypanosoma Brucei. Journal of Veterinary Science, Vol. II. No. 2, p. 184.

STOCKMAN STEWART . Anthrax. Journal of Veterinary Science, Vol. I, No. 4, p. 432.

THEILER . . Transmission and inoculability of Spirillosis in cattle. Journal of Veterinary Science, Vol. I, No. 4, p. 421.

TUCK, GNOH LEAN . Observations on some worms formed in the Aortas of buffaloes and bullocks. Journal of Veterinary Science, Vol. I, No. 1, p. 69.

WALKER, G. K. . A Preliminary Note on "Gillar," a disease affecting sheep and goats. Journal of Veterinary Science, Vol. I, No. 4, p. 410.

PROGRAMMES OF WORK FOR 1907-08.

PROGRAMMES OF WORK OF THE VARIOUS SCIENTIFIC DEPARTMENTS FOR THE YEAR 1907-08, AS APPROVED BY THE BOARD ON THE 20TH DECEMBER 1907.

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1. The Imperial Institute, London, and the Department of Economic Products, Calcutta.

1. Samples of Indian Turpentine will be reported on by the Director of the Imperial Institute.

2. Investigations of myrrh, frankincense, byssabol, habaghadi and allied products are being prosecuted.

3. Ngai Camphor from *Blumea balsamifera* is under study.

4. The fats of the seeds of various nutmegs are being studied by the Curator, Industrial Section, Indian Museum.

5. The dye stuffs, *Hibiscus sabdariffa*, *Onosma echioides*, *Thespesia populnea* and *Baccaurea sapida*, are still under study at Leeds and the Imperial Institute.

6. Investigations on the tanning barks of *Shorea robusta* and *Terminalia tomentosa* will be carried on by the Director of the Imperial Institute.

7. A preliminary report on the races of jute will be issued conjointly with Mr. R. S. Finlow, Fibre Expert to the Government of Eastern Bengal and Assam.

8. Pharmacological investigations will be continued on the Aconites by the Director of the Imperial Institute and Professor Cash.

9. The study of the following indigenous Indian drugs, by physicians in India, will be continued:—*Adhatoda vasica*, *Alstonia scholaris*, *Cæsalpinia bonducella*, *Calotropis procera*, *Embelia ribes*, *Ipomœa hederacea*, *Picrorhiza kurrooa*, *Podophyllum emodi*.

10. The collecting of information of the gentianaceous bitters of India will be prosecuted.

11. Chemical analyses are in progress at the Imperial institute of *Hyoscyamus niger*, *H. reticulatus*, *Datura stramonium* and *Datura fastuosa*, sufficient material having been supplied from India. The idea underlying the investigation is the possibility of sending supplies of these from India to the European drug market.

12. Material sent to the Imperial Institute for investigations on Strychnos beans, etc., will be examined there.

13. A report on the races of Juar (*Andropogon sorghum*) in India will be drawn up during the year by the Reporter on Economic Products.

14. Rice grain will be subjected to chemical examination by the Curator, Indian Museum, Industrial Section, with special reference to its uses as a material for making sizes, and to its nutritive value.

15. A report on the Yams (*Dioscorea* spp.) of India will be drawn up during the year by the late Director of the Botanical Survey and the Reporter on Economic Products.

16. The origin of reeds of native pens will be reported on.

17. Pottery clays by arrangement with the Director of the Geological Survey have been collected by the Reporter on Economic Products and will be examined chemically by Professor Dunstan.

18. Completion of an investigation on opium alkaloids, including an improvement of the method of extracting morphine and codeine from waste opium. (Imperial Institute.)

19. Further examinations of the tanning properties of *Cæsalpinia digyna* pods, arranged in conjunction with the Forest Department. (Imperial Institute.)

20. Suggested examination of red and white Rangoon beans in order to see what amount of prussic-acid-forming glucoside they contain. (Imperial Institute.)

21. Suggested examination of sources of oil, in which connection the Director of the Imperial Institute remarks: "At present there is great scarcity of oilseeds in the United Kingdom, and these materials are selling at high prices. It would be well, therefore, to send to the Imperial Institute for examination any little known oilseeds which are likely to be obtainable in commercial quantities either as forest products or by cultivation. In this connection, it may be mentioned that owing to the introduction of methods depending on the use of solvents for the extraction of oils, it is now possible to use commercially many materials of this class which were formerly unsaleable as oil-yielding products, such as Soy beans and oil-cakes prepared by native methods and containing eight per cent. of oil or more."

22. Examination of supposed pitch-blende at the request of the Director of the Geological Survey. (Imperial Institute.)

2. Meteorological Department.

Astronomy.—The strengthening of the staff at Kodaikanal through the arrival of the Assistant Director will enable the routine work to be extended. It is proposed to include—

(*a*) photographing of the sun in monochromatic light by means of the spectroheliograph fed by a twelve-inch lens of twenty feet focal length ;

(*b*) photographing spot-spectra made with a plane or a parabolic grating fed by a six-inch lens of forty feet focal length :

(*c*) spectroscopic visual observations of sunspots and prominences by means of an Evershed spectroscope on a six-inch equatorial ;

(*d*) photographing the sun in ordinary light with a photoheliograph.

The programme arranged with the International Solar Union, co-operation with which had previously been decided upon, will probably involve the detailed examination of the portion of the spectrum from *b* towards *F*.

Meteorology.—*Study of the conditions determining the amount of Monsoon Rainfall and Cold Weather Precipitation.*—As already stated in the report for 1906-07, the area over which the weather appears to be connected with that of India, is considerably larger than had formerly been supposed, and it is proposed to investigate further the relationships between the meteorological conditions of India and those of other parts of the world : the influence of solar activity also demands additional examination. The mechanism by which the meteorological features are controlled is very obscure and it seems necessary to accumulate empirical knowledge as to relationships for some time before making any attempt to explain the physical processes in action.

The extension of the area under examination has somewhat diminished the relative importance, from the standpoint of India, of the production of weather maps of the whole Indian Ocean, especially in view of the scantiness and inaccuracy of the data available. A report as to the possibility of devising a satisfactory method of preparing a monthly map has been submitted to the Government of India.

Study of the upper atmosphere.—*Kites.*—It is proposed to continue the experimental work which has been carried out at Belgaum in the course of the past year, and to learn more of the conditions of temperature, humidity and wind in the free air.

Balloons.—Some experience has now been gained as to the best material and methods for making light balloons, for the purpose of observation of velocities and directions of the upper air currents. Results already obtained have indicated that a considerable amount of information may be given by these balloon flights, and it is intended, therefore, to continue the work during the coming year. Arrangements are in hand also for using small balloons to carry up light meteorographs to considerable heights during times of little wind and to determine from the records so obtained the conditions of the free air over the plains at times when lack of wind precludes the use of kites. Information may thus be obtained by which the reduction of the barometer readings at high level station to sea level may be more accurately done than is at present possible.

Cloud Observations.—It is proposed to give a special training to three or four observers in different parts of India so that they may make cloud observations of a more accurate character than has hitherto been done ; the results will be used in connection with the general enquiry regarding the higher air currents which is now in hand.

Daily weather work.—*Storm and flood warning.*—The preparation of files of weather charts showing pressure at 8 hours, changes of pressure since the previous day and the resulting rainfall should be continued, and the winter tour for 1906-07 of the flood and storm warning officer has been arranged with a view of ascertaining more closely the conditions and needs of the ports on the west coast in order that improvement may be made during the coming year in the methods of warning for stormy weather.

Solar Radiation.—Observations of the absolute value of solar radiation by means of Angstrom's electrical compensation pyrheliometers have been begun in Simla, and it is proposed to start systematic observations at an adjacent station in the plains also as soon as opportunity offers. The department has been presented by Dr. Sven Hedin with a pyrheliometer of the same type, but up to the present it has not been possible to send it to Simla from Srinagar, where it was left by Dr. Hedin.

Atmospheric Electricity.—For some little time measurements have been made thrice daily of the atmospheric potential gradients, and values of positive and negative ionisation and of the mobility of ions have been obtained periodically by means of Ebert's apparatus. This work should be continued, and it is hoped that the important task of ascertaining the sign and measuring the amount of electrical changes on rain and snow during various types of weather will be well in hand at the close of year 1907-08. Somewhat similar work has been in operation at Calcutta, and will be continued as far as circumstances permit.

Seismography.—The recording of earth movements by the Japanese seismograph which was lent to the department by Dr. Omor in 1905 should be continued, and when the more modern equipment, which has been on order for some time, has arrived from Japan all records of shock will be made in three directions, two horizontal and one vertical.

Among investigations which will be undertaken if circumstances permit are :—

(1) The photographic measurement in Simla of heights of clouds.

(2) The systematic examination of published seismograph records from various places, and their correlation with those produced in Simla.

Terrestrial Magnetism.—The routine work of the Bombay Observatory now includes—

(*a*) the measurements of the magnetic elements at Alibag, both by visual observation and by means of self-recording instruments ;

(*b*) the tabulation at Colaba of the data so obtained.

The magnetic records of the Colaba Observatory are being prepared for publication, and it is hoped that this work will be completed during the year. In addition to questions involving ordinary tabulation there are several which required special examination.

3. Survey of India (Research Work).

Gravimetric Survey.—Pendulum observations will be taken on the Mysore plateau and possibly on the Nilgiri hills. Observations of the plumbline will be taken round the Gulf of Cambay, and in the desert north-west of Deesa.

Magnetic Survey.—Colaba Observatory under the Meteorological Reporter and the four observatories under the Surveyor-General will continue to work: observations will be taken at 24 Repeat stations, and the preliminary survey will be continued.

Solar Photography.—Photographs of the sun will be taken daily at 10 A.M. and 4 P.M. at Dehra Dun, as has been done since 1879 in conjunction with Greenwich.

Himalayan Geography.—In conjunction with the Geological Survey, the Survey of India will publish a paper summarising the present position of Himalayan Geography and Geology.

4. Geological Survey.

(1) Mapping of unsurveyed areas in the Shan States with examination of the lead-zinc mines in the Southern States.

(2) Continued examination of the tin deposits in Mergui, Tavoy and Karenni with a general geological survey of the areas in which they occur.

(3) Continued survey of the oil-bearing regions in the Irrawaddi valley and in the Arakan districts.

(4) Survey of the volcano of Popa in the Myingyan district of Burma.

(5) Continued examination of the copper-bearing belt in Singhbhum, with a Survey of the associated Dharwarian and Gneissose rocks.

(6) Examination of manganese-mines in the Central Provinces, and newly opened deposits of manganese-ores in the Bellary district.

(7) Extension of the geological map over unsurveyed areas in the Chanda and Raipur districts.

(8) Further extension of the geological map over previously unsurveyed areas in Central India and neighbouring states of Rajputana.

(9) Geological Survey of the Bugti hills with special reference to the fossil-vertebrate-bearing Tertiary rocks.

(10) Chemical work on various brines from the Sambhar Lake, and on the samples of silt-bearing water collected from the Indus river.

(11) Palæontology of—

(*a*) The Liassic rocks of Baluchistan.

(*b*) The Lower Tertiary marine beds, specially of Baluchistan.

(*c*) The Lamellibranchs of the Ranikot series of Sind.

(*d*) The Cambrian Ordovician and Silurian of Spiti.

(*e*) The Exotic blocks of the Bhot Mahals of Kumaon.

5. Botanical Survey.

I.—Country under the Superintendent of the Royal Botanic Garden, Calcutta.

(*a*) **Bengal.**—An endeavour will be made to make a representative collection of the plants found in one or more of the Districts of Bengal to be utilized, it is hoped, ultimately in the preparation of District lists.

(*b*) **Assam and Burma.**—The same policy will be pursued, as far as possible, within Assam and Burma.

II.—Survey of Bombay.

Mr. Gammie, the officer in charge of the Survey of Western India, proposes, during the year 1907-08, to continue special investigations on the Ghats, some of the Deccan Districts, Guzerat and possibly Sind, and also to continue researches on the cottons and fodder grasses of the Bombay Presidency.

III.—Survey of Southern India.

The Government Botanist, Madras, states that there will be no room for tours in Systematic Botany in 1907-08 as he expects to apply for 18 months' leave from 1st April 1907.

IV.—Survey of Northern India.

The Economic Botanist to the Government of the United Provinces states that he has no programme of operations of the Botanical Survey for 1907-08.

6. Agricultural Departments.

SECTION 1.—PUSA AGRICULTURAL RESEARCH INSTITUTE.

(A) **Agricultural Chemistry.**—The Agricultural Chemist to the Government of India will be employed, among other things, on the investigation of the following problems :—

(1) The availability of plant food (more especially phosphates) in soils, with reference to Dr. Dyer's method of determination will be studied in the Laboratory and Pot-culture House. The experiments will be extended to natural orders of plants other than the *Gramineæ*.

(2) The composition of rain-water, dew and drainage water will be further investigated. The percolation through the soil will be determined in the special drain-gauges at Cawnpore and Pusa. In addition, a series of tests will be made to determine, throughout the year, the amount of moisture at varying depths in the soil.

(3) An investigation will be made into the nature and quantity of gases contained in soils at various depths.

(4) Amongst minor investigations may be mentioned (*a*) the testing of calcium cyanamide and calcium nitrate as manures; (*b*) the analysis of sugarcane juice; (*c*) the conditions under which glucosides are formed in *Andropogon sorghum*, *Manihot utilissima* and *Linum usitatissimum*.

(5) A beginning will be made to determine, by ultimate analysis, the actual composition of the ordinary field and garden crops—the object being to obtain definite information regarding the manure requirements of each crop.

(6) Analyses of the silt of selected rivers with regard to its composition and value for agricultural purposes will be continued.

(B) Mycology.—The programme of the Imperial Mycologist includes the following subjects : —

(1) The investigation of soil fungi in their relation to plant life, with special reference to the symbiotic relation between certain fungi and the roots of a number of higher plants,

and also the part played by fungi in the decomposition of organic matter in the soil.

(2) The investigation of the wilt-producing fungi of pigeon pea, pepper and other crops.

(3) The study of sugarcane diseases.

(4) The investigation of cereal and flax rusts, more particularly of wheat.

(5) The study of some Indian smuts.

(6) The study of a number of other fungus diseases of crops.

(7) The continuance of the systematic survey of the Indian fungi.

(C) Entomology.—

(1) The principal work of the Imperial Entomologist will be the trial of remedies for injurious crop pests on experimental farms, based upon the results of the investigations of previous years, which have been published in a book on Indian Insect Pests.

(2) The treatment of insect pests infesting the crops grown at Pusa will be continued.

(3) The work at the insectory will include (*a*) an investigation of the relation of climatic changes to the life histories of insects; (*b*) the study of methods of increasing the beneficial action of parasitic insects; (*c*) the testing of the action on insects of substances innocuous to cattle; and (*d*) the working out of the life histories of crop pests.

(4) The insect survey of India will be continued, assistance in the identification of insects being obtained from workers in other countries.

(5) The study of biting flies will be continued.

(6) Assistance will be given in measures for the suppression of boll-worm in cotton in the Punjab, the scheme including the growth of trap crops, the introduction of beneficial parasites from other parts of India and other remedies.

(D) Economic Botany.—The Imperial Economic Botanist will devote his attention to the following subjects :—

(1) The collection and investigation of fibre-yielding plants.

(2) The improvement of Indian wheat, more particularly the rearing of new varieties by cross-breeding.

(3) The study of varieties of Indian tobacco, barley and wheat.
(4) Permanent experiments on the treatment of Indian fruits.
(5) The study of varieties and cultivation of cassava.

(E) **The Experimental Farm.**—

(1) The regular series of tests under uniform methods of treatment will be continued in order to prepare the way for comparative experiments.
(2) A series of permanent field experiments will be started if the land is found to be uniform.
(3) A systematic trial will be made of the efficiency of field agricultural implements, native and foreign, in use in India.
(4) The cultivation of selected varieties of sugarcane will be continued.
(5) The improvement of the herd of indigenous cattle for the supply of breeding bulls, and the testing of the Montgomery dairy herd for their acclimatization as milch cattle, will be continued.

(F) **General.**—In each special branch arrangements have been made for the training of probationers for provincial departments. It is anticipated that the College for post-graduate study will be ready to open by the end of 1907.

SECTION II.—SPECIAL INVESTIGATIONS.

1. The improvement of Indian cottons and wheats will be continued, in conjunction with provincial departments, in accordance with last year's programme. The scheme for the improvement of Indian tobacco will largely remain in abeyance until the appointment of a specialist for this purpose.

2. Other crops that are the subject of special investigation are (*a*) Tea, under the scientific department of the Indian Tea Association; (*b*) Indigo, under the scientific department of the Behar Planters' Association; and (*c*) Jute, under the fibre expert to the Government of Eastern Bengal and Assam. The programmes of work are similar to those of last year.

3. The trial of commercial fertilizers for Indian crops will be continued, more particularly the testing of mineral fertilizers for cotton sulphate of ammonia for sugarcane, and the introduction into more common use of saltpetre as a manure.

SECTION III.—PROVINCIAL DEPARTMENTS OF AGRICULTURE.

The programmes for next year generally follow those described in last year's programme placed before the Board of Scientific Advice, but the following important additions may be noticed:—

(1) In the United Provinces, two new agricultural stations will be started, one at Aligarh for the improvement of cotton, and the second at Partabgarh for the study of rice and sugarcane. Experiments will be undertaken for the reclamation of alkali lands by the application of gypsum.

(2) In the Punjab a new agricultural station will be started at Jullunder. The campaign against the cotton boll-worm will be continued. A start will be made with a systematic survey of the province with reference to the possibility of extending minor irrigation works, such as wells, water channels and embankments. An enquiry into alkali lands in the Chenab and Jhelum Colonies will be undertaken.

(3) In Bombay a new botanical station has been started at Bassein. The survey of the cottons of the Presidency will be continued, and a survey of the wheats initiated. A comprehensive scheme of experiments in sugarcane has been started at the Manjri Station.

(4) In Bengal, new agricultural stations will be opened at Bhagalpur and Bankipur. The investigation of Tassar silk will be undertaken at Chaibassa.

(5) In Madras, the study of the cottons known as "northerns" will be taken up at the Nandyal Agricultural Station. The botanist will extend his study of root parasites to the haustoria of *Cansjera*, *Olax*, *Ximenia* and *Opilia*. Special work will be undertaken to attempt to arrest the spread of the palmyra disease in the Godavari District.

(6) Schemes have been completed for the establishment of Central Research Stations and Agricultural Colleges at Poona (Bombay), Lyallpur (Punjab), Cawnpore (United Provinces), Bhagalpur (Bengal), Coimbatore (Madras), Nagpur (Central Provinces) and Mandalay (Burma). A staff of three European specialists has been sanctioned for each.

7. Forest Department.

1. Further examination of tannin extracts, more particularly with extract obtained from barks of common Indian species of trees and treated by the decolorising process suggested by the Director, Imperial Institute, will be made.

2. The report of the expert engaged to enquire into the possibility of manufacturing wood and bamboo pulp in Burma on a commercial basis, has been received, and it is hoped that a profitable industry may shortly be started.

3. The collection for analysis of the latices of rubber-producing species will be continued.

4. The enquiry into the utilisation of the less valuable kinds of timber as railway sleepers will be continued and experiments will be made to ascertain whether any preserving process can be successfully used. A practical experiment will be made with sleepers obtained from *Dipterocarpus sp.* from Burma and the Andamans.

5. An enquiry regarding lac, and the best season for gathering it, is in progress and will be continued.

6. The collection of specimens of timber and other forest products will be continued for supply to the Reporter on Economic Products, and seeds of the more important indigenous species will be collected and sent, for experimental cultivation, to various British Colonies and Foreign countries.

7. Memoirs and Records of the Forest Department setting forth the results of investigations into various subjects affecting the progress of Indian Forestry will be published from time to time.

8. Various investigations will be made by the officers of the Imperial Forest Research Institute, Dehra Dun, including the following:—

An examination of the teak forests and plantations of Burma with special reference to the compilation of forest working-plans, and rates of growth of different species and enquiry into the possible utilisation of "In" (*Dipterocarpus tuberculatus*), and other so-called inferior species for sleepers, wood pavement and building.

Investigation in the United Provinces into the attacks of *Scolytidæ* on the Deodar, Spruce, Blue pine and Silver fir and the

wood-boring *Cerambycidæ* of the Oaks, the cone-mining pests of the Deodar and other conifers, the defoliating pests of the conifers and oaks, and the Autumn stages of the Silver fir and Spruce *Chermes*.

Further investigations into the flora of the Sonthal Parganas in order to complete a local flora of Chota Nagpur and a study of the morphological nature of the coppicing of sal (*Shorea robusta*).

The grasses of Savannah tracts in Bengal will be examined with special reference to their difference in burnt and unburnt areas, and a study will be made of the timber of different species of *tun* and *Grewia*, to ascertain which yield the most valuable wood.

8. Natural History Section, Indian Museum.

The Officiating Superintendent proposes to continue his work on the invertebrate fresh water fauna of India, and on the distribution of the lesser terrestrial fauna of the Himalayas. Arrangements have been made whereby one of the Assistants in the Museum shall be in the field collecting Zoological specimens during the greater part of the year. In the Entomological Laboratory the Entomological Assistant will pay special attention to the naming and arrangement of large collections of Hymenoptera and Hemiptera recently acquired, and to the sorting out of specimens in other groups which are to be sent to specialists in Europe and America for identification. It is hoped that a systematic study of the rats concerned or possibly concerned with plague may be commenced by the collection and mensuration of specimens from different parts of India.

9. Civil Veterinary Department.

1. An investigation into the etiology, course and prevalence of "Kumri" or Paralysis among horses. A disease which causes heavy loss in certain parts of India, especially in the Madras Presidency.

2. **Trypanosomiasis.**—This disease will be further studied in the horse, cattle and camel.

The points to which attention will be directed are :—

(*a*) The Natural History of the Trypanosome.

(*b*) The identity or otherwise of the Trypanosome infecting the horse, ox and camel.

(*c*) The rôle played by biting flies in the spread of the disease, with a study of such flies.

(*d*) The course of the disease in the camel.

(*e*) More definite information regarding the nature and extent of the tracts in which the disease is prevalent.

(*f*) Methods of prophylaxis and treatment.

3. **Piroplasmosis.**—Further observation will be made, as occasion arises, regarding the prevalence of this disease in cattle, horses and other animals, and its effects as a primary or secondary disease.

4. An enquiry into the comparative value of the serum and vaccine methods of prophylaxis against Anthrax, Charbon symptomatique and Hæmorrhagic Septicæmia, considered in conjunction with the peculiar conditions of the country and the facilities at the disposal of the Department.

5. **Hæmorrhagic Septicæmia.**—A further enquiry into the prevalence and course of this disease and the methods of establishing a correct diagnosis in the field.

6. Attention will be paid to any other disease to which during the year special attention is drawn and opportunity of study presented.

7. The preparation of sera, anti-toxins and vaccines will be continued.

The programme may appear an over-extensive one, but at present there are no facilities for the continuous and systematic study of any one disease, and the progress of investigation depends on the material which may be supplied to the Laboratory and on the opportunities which may arise of carrying out observations in the field.

APPENDIX.

APPENDIX.

ECONOMIC INVESTIGATIONS CONDUCTED FOR INDIA AT THE IMPERIAL INSTITUTE DURING THE YEAR ENDING 30th SEPTEMBER 1907.

BY

W. R. DUNSTAN, M.A., LL.D., F.R.S.,

Director of the Imperial Institute.

Numerous investigations relating to the composition and utilisation of Indian products have been conducted in the Scientific and Technical Department of the Imperial Institute during the past year at the request of various departments in India, conveyed, for the most part, through the Officiating Reporter on Economic Products to the Government of India.

The more important of these are briefly described below :—

Drugs.—*Aconites.*—The investigation of the various Indian aconite roots referred to in last year's report has been continued, but the work has been somewhat delayed by the pressure of other Indian investigations, particularly that on opium alkaloids, referred to below.

Solanaceous Plants.—Progress has been made with the isolation and characterisation of the alkaloids contained in the various species of *Hyoscyamus* and *Datura* which have been received from the Officiating Reporter on Economic Products.

Opium.—A new process for the manufacture of morphine and codeine from waste opium has been devised for use at the Opium Factory at Ghazipur. Preliminary commercial trials of this process were carried out at the Imperial Institute in the presence of the Factory Superintendent, and as these proved the feasibility of using the process in India, plant suitable for operations on the large scale has been designed and is at present being constructed in London, for despatch to India.

Strychnos species.—The seed of *Strychnos potatorum* is at present under examination in continuation of this enquiry.

Rubber.—Six samples of rubber have been received for examination during the year. Of these the best was a specimen of Para rubber (*Hevea brasiliensis*) from the Mergui Plantation, Burma, which proved to be of excellent quality. It compared favourably in composition and properties with Para rubber from plantations in Ceylon and the Federated Malay States, and was valued in London at 5*s.* 6*d.* per pound, at a time when "fine hard Para rubber" from South America was quoted at 5*s.* 2*d.* per pound.

Two samples of *Ficus elastica* rubber from the Kulsi Plantation were received. The first of these contained a rather high percentage of resin, but was valued at 4*s.* 3*d.* to 4*s.* 6*d.* per pound. The other sample consisted of "mat" rubber, and was weak, sticky and of inferior quality. It was valued at 2*s.* to 2*s.* 3*d.* per pound.

At the end of the year there remained under examination two samples of Ficus rubber and one of Ceara rubber.

Fibres.—*Cotton.*—A specimen of so-called "Buri Kapas" from the Singbhum District, Bengal, was found to be of American type and of satisfactory quality. Another sample from the same district, labelled "Lambua cotton," was of good colour and would be readily saleable. Three samples of "Caravonica" cotton grown from Australian seed were forwarded by the Director of Agriculture, Madras. These were examined and found to be similar to fine qualities of improved American Upland varieties.

Seven samples of cotton of various kinds, including native Indian, American, Peruvian and Caravonica, which were forwarded for examination by the Economic Botanist, Bombay, were, on the whole, of rather poor quality. Their chief defects were the presence of stains, apparently caused by insect pests, and of crushed seed due to imperfect ginning. It was recommended that means should be taken for combating the attacks of insect pests and that greater care should be exercised in ginning.

Five samples of American cotton, grown in the Myingyan District, Burma, were stained and partly immature, but were nevertheless of promising quality and could probably be improved by greater care in cultivation and the adoption of measures against insect pests.

Urena species.—A small sample of Urena fibre from Neltigandi was examined. It was of irregular length and not very well prepared but was regarded by commercial experts as suitable for spinning and

of probable utility for mixing with jute. It was recommended that greater care should be taken in retting, and that attention should be given to the length of the fibre.

Hibiscus species.— A sample of Hibiscus fibre, grown in the Ganesh-khind garden, Kirkee, was examined. It was badly prepared, but of promising quality. A recommendation was made that more care should be taken in retting the fibre.

Flax.—A sample of unretted flax straw grown from Riga seed at the Bankipore Agricultural Experiment Station was examined and compared with a standard specimen of Belgian flax. The straw was well grown, but rather coarser than the Belgian product and somewhat woody. It was considered that the seed had not been sown thickly enough, and suggestions were made as to the amount to be sown per acre and the age at which the straw should be gathered.

Musa Sheaths.—A consignment of the sheaths of *Musa textilis* was examined and submitted to technical experts. It was reported that the material would probably not realise more than £3 to £4 per ton for paper making, but that possibly the sheaths could be utilised for packing machinery and furniture.

Agave and Furcræa fibres.—Two samples of Agave fibres and one of Furcræa from the Anantapur District, and two specimens of Agave fibres from Assam are at present under investigation.

Dyes.—The investivation of four Indian dyestuffs has been completed by Mr. A. G. Perkin, F.R.S., of Leeds University, to whom they were referred.

The root bark of *Onosma echioides* was found to contain a red dye similar to the Alkannin, which occurs in alkanet root (*Alkanna tinctoria*). The latter is still used to some extent in commerce for dyeing oils, etc., but there is no prospect of finding a similar outlet for the *Onosma* root bark.

The flowers of *Hibiscus Sabdariffa* contain a yellow dyestuff, which gives poor shades, and this material cannot be recommended for use in dyeing.

The flowers of *Thespesia lampas* contain the well-known dye quercetin, but not in sufficient quantity to enable this material to compete with the natural yellow dyestuffs still employed to some extent in Europe.

The leaves and bark of *Baccaurea sapida* proved to possess no tinctorial property, and they are probably used in India only as an adjunct to other dyestuffs. This point is being enquired into by the Officiating Reporter on Economic Products.

Tanning Materials.—The enquiry into the commercial value of the samples of extracts made from the bark of *Rhizophora mucronata* at the Tanning Extract Factory at Rangoon was completed. This material proved to be fairly rich in tannin, but was too dark coloured to be suitable for use as a tanning agent without special treatment, as to which suggestions were made.

Oils and Oil-seeds.—The two oils received were derived from the seeds of *Amoora rohituka* and *Calophyllum tomentosum*. The first of these was compared with a sample of this oil examined at the Imperial Institute some years ago and proved to be quite different in properties, and information was asked for as to the authenticity of the sample. The oil was not of good quality and not likely to be of high commercial value.

The sample of oil of *Calophyllum tomentosum* was of poor quality and appeared to have been overheated in the course of preparation. It would probably be worth about £1 per ton less than cotton seed oil for soap-making.

Samples of the seeds and fats obtained from several species of *Bassia* were received and are at present under examination. The Bassia fats are important as it seems probable that they will meet the requirements of certain manufacturers.

Turpentine Oil.—This enquiry is still in progress. As the turpentine oil from *Pinus longifolia* appears to possess characteristic properties, a complete chemical examination of it is being made with a view to the identification of its constituents.

Resins.—A complete chemical examination of the resin of *Pinus longifolia* is being made as a part of the turpentine oil investigation.

A sample of black dammar resin was received and is at present under technical trial.

Foodstuffs.—*Coffee.*—Two samples of coffee, grown on the Arabidecool estate, Kadur District, Mysore, were submitted by the Agri-Horticultural Society for examination. The first sample was part of the 1904-5 crop from unmanured land. The second sample

was from the 1905-6 crop from the same land, which had in the meantime been manured with basic slag, saltpetre and poonac. Comparison of the two samples showed that as the result of manuring there were slight increases in the density, size and weight of the beans and in their content of alkaloid.

Prussic Acid in Plants.—Considerable progress has been made during the year with the investigation of cyanogenesis in plants, and a further study of the constitution of the glucoside phaseolunatin, and of the nature of the enzyme associated with it in flax, cassava and the beans of *Phaseolus lunatus* has been made. The results are given in a paper communicated by Professor Wyndham R. Dunstan and Drs. Thomas A. Henry and S. J. M. Auld to the Royal Society (*Proc. Roy. Soc.*, 1907, B, LXXIX, 315), copies of which have been sent to the Officiating Reporter on Economic Products.

Professor Dunstan has also published, in the "Proceedings of the Chemical Society" (1907, xxiii, 168), a preliminary note on the origin of the prussic acid of Para rubber seeds (*Hevea brasiliensis*), which indicates that these seeds contain phaseolunatin or some similar glucoside.

Some further work has also been done for His Majesty's Board of Agriculture on the subject of Rangoon beans. The early work by various investigators on white Rangoon or Burma beans all indicated that this variety yielded no prussic acid or mere traces, and that it could be safely recommended for use as a feeding stuff (compare "Bulletin of the Imperial Institute," 1906, iv, 329). Recently, however, white Rangoon beans have been sold in this country which yielded as much as 0·025 per cent. of prussic acid. This matter is still under investigation in consultation with the Board of Agriculture.

Minerals.—*Manganese Ores.*—The supplementary work on these ores, asked for by the Director of Geological Survey, involving the determination of the amounts of nickel and cobalt oxides, alkalis baryta, arsenious oxide and water, present in certain selected ores, has been completed and a supplementary report on the subject has been forwarded.

Laterites.—A report giving the results of the analyses of a series of laterites sent by the Director of the Geological Survey, has been forwarded to India and some further information as to the commercial

value and industrial possibilities of these laterites is now being obtained.

Concentrate supposed to contain pitchblende.—This concentrate from the Tsagpo river, was received from the Director of the Geological Survey. It was found to be slightly radio-active and to contain a trace of monazite and some thorium-uranium mineral. The sample was too small to permit of the identification of the latter.

Pottery Clays.—The preliminary examination of these has been completed, and a report is in preparation.

Miscellaneous.—The calorific value of cow-dung cakes is being determined at the request of the Director of Agriculture, Bombay, in order to ascertain the value of this material as fuel.

A considerable number of enquiries relating to the utilisation of Indian products has been received during the year both from firms in India and in this country, and in some cases these have been accompanied by samples of products for examination. The specimens so received include *inter alia* rubber, cotton, minerals and mother-of-pearl shells.

The following reports have been forwarded to India during the year :—

Report on Coffee from the Arabidecool Estate, Kadur District, Mysore.

Report on Laterites from the Central Provinces, India.

Report on Tanning Extracts from the barks of *Shorea robusta*, *Terminalia tomentosa* and *Rhizophora mucronata*.

Report on the Tanning value of extract from *Xylia dolabriformis*.

Report on Sheathes of *Musa textilis*.

Report on the Colouring Matter of the roots of *Onosma echioides*.

Report on the Colouring Matter of the flowers of *Hibiscus Sabdariffa*.

Report on the Colouring Matter of the flowers of *Thespesia lampas*.

Report on the leaves and bark of *Baccaurea sapida*.

Report on a concentrate supposed to contain pitchblende.

Report on the Oil of *Calophyllum tomentosum* from India.

Report on the Oil of *Amoora rokituka* from India.

Report on Para rubber (*Hevea brasiliensis*) from Mergui.
Report on *Ficus elastica* rubber from the Kulsi plantation.
Report on Cotton from Singbhum District, Bengal.
Report on Lambua cotton from Singbhum District, Bengal.
Report on Cotton from Burma.
Report on a new process for the preparation of Morphine and Codeine from Indian opium.
Report on Flax from Bengal.
Report on Cottons from Madras.
Report on Hibiscus fibre from Bombay.
Report on the Floss of *Calotropis procera*.
Report on *Orthanthera viminea* fibre.
Report on Cottons from Bombay.
Report on Urena fibre from India.

The following articles, dealing with subjects of importance to India, have been printed in the "Bulletin of the Imperial Institute" during the year:—

	Years.	Vol.	Page.
Fibre of *Nannorhops ritcheana* from India	1906	4	251
Cyanogenesis in Plant	1906	4	329
Oil from the Seeds of the Ceara rubber tree	1906	4	365
Latex and rubber of *Parameria glandulifera* from India	1907	5	14
Graphite; its occurrence and uses	1907	5	77
Coffee cultivation in Mysore	1907	5	85
Utilisation of the Soy bean	1907	5	86
Insects and other cotton pests and methods suggested for their destruction	1907	5	140
American Tree cottons in India	1907	5	185
Extension of the cultivation of Jute and similar fibres in India	1907	5	266
Manganese Ores; their uses, occurrence and production	1907	5	273
The Jaipur and Nazira coalfields, Upper Assam	1907	5	303

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(3) Annual Report of the Industrial Section, Indian Museum.

II.—Meteorological Department.

Government of India Office.

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(3) The Monthly Weather Review.
(4) The Annual Summary.
(5) The rainfall of India.
(6) Indian Meteorological Memoirs.

Bengal Office.

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(2) Monthly rainfall tables and summaries of the chief features of the weather of the month over Bengal.

Bombay Office.

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(2) Monthly abstracts of the Bombay observations (Bombay Gazette).

Madras Office.

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(2) Monthly rainfall tables (Madras Gazette).

Allahabad Office.

(1) Monthly Weather summaries (United Provinces Gazette).
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Lahore (Simla) Office.

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III.—Geological Survey.

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(2) Records of the Botanical Survey, Vols. I—III, and Vol. IV, Nos. 1—3.
(3) Annual Report of the Royal Botanic Garden, Calcutta.
(4) Annals of the Royal Botanic Garden, Calcutta, Vols. I—X.

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(3) *The Indian Forester.*—A monthly Journal of Forestry, Agriculture, Shikar and Travel. This is a Departmental Journal published monthly.

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